MET Laboratories, Inc. *Safety Certification - EMI - Telecom Environmental Simulation*
914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230-3432 • PHONE (410) 354-3300 • FAX (410) 354-3313
33439 WESTERN AVENUE • UNION CITY, CALIFORNIA 94587 • PHONE (510) 489-6300 • FAX (510) 489-6372
3162 BELICK STREET • SANTA CLARA, CA 95054 • PHONE (408) 748-3585 • FAX (510) 489-6372
13301 MCCALLEN PASS • AUSTIN, TEXAS 78753 • PHONE (512) 287-2500 • FAX (512) 287-2513

November 26, 2014

Roku
12980 Saratoga Ave.
Saratoga, CA 95070

Dear Monika Painuly,

Enclosed is the EMC Wireless test report for compliance testing of the Roku, RC2X as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Title 47 of the CFR, Part 15, Subpart B and ICES-003, Issue 5 August 2012 for Unintentional Radiators, and Part 15.407 Subpart E and RSS-210, Issue 8, Dec. 2010 for Intentional Radiators.

Thank you for using the services of MET Laboratories, Inc. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,
MET LABORATORIES, INC.

Jennifer Warnell
Documentation Department

Reference: (\Roku\EMCS84062-FCC407 Rev. 1)

Electromagnetic Compatibility Criteria
Test Report

for the

Roku
Model RC2X

Tested under
the Certification Rules
contained in
Title 47 of the CFR, Part 15, Subpart B& ICES-003
for Unintentional Radiators
and
15.407 Subpart E & & RSS-210, Issue 8, Dec. 2010
for Intentional Radiators

MET Report: EMCS84062-FCC407 Rev. 1

November 26, 2014

Prepared For:

Roku
12980 Saratoga Ave.
Saratoga, CA 95070

Prepared By:
MET Laboratories, Inc.
914 W. Patapsco Ave.
Baltimore, MD 21230

Electromagnetic Compatibility Criteria
Test Report

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and
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for Intentional Radiators

Andy Shen, Project Engineer
Electromagnetic Compatibility Lab

Jennifer Warnell
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of Parts 15B, 15.407, of the FCC Rules under normal use and maintenance.

Asad Bajwa,
Director, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	November 19, 2014	Initial Issue.
1	November 26, 2014	Revised to reflect engineer corrections.

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List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**ert**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**k**ilo**h**ert**z**
kPa	**k**ilo**pa**scal
kV	**k**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**microh**enry
µ	**microf**arad
µs	**micros**econds
PRF	**P**ulse **R**epetition **F**requency
RF	**R**adio **F**requency
RMS	**R**oot-**M**ean-**S**quare
TWT	**T**raveling **W**ave **T**ube
V/m	**V**olts **per m**eter
VCP	**V**ertical **C**oupling **P**lane

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Roku RC2X, with the requirements of Part 15, §15.407. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the RC2X. Roku should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the RC2X, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.407, in accordance with Roku, purchase order number 325443. All tests were conducted using measurement procedure ANSI C63.4-2003.

FCC Reference	IC Reference RSS-210 Issue 8: 2010; RSS-GEN Issue 3: 2010	Description	Results
47 CFR Part 15.107 (a)	ICES-003 Issue 5 August 2012	Conducted Emission Limits for a Class B Digital Device	Not Applicable
47 CFR Part 15.109 (a)	ICES-003 Issue 5 August 2012	Radiated Emission Limits for a Class B Digital Device	Compliant
Title 47 of the CFR, Part 15 §15.203	N/A	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	RSS-GEN (7.2.4)	Conducted Emission Limits	Not Applicable
Title 47 of the CFR, Part 15 §15.403 (i)	RSS-Gen (4.6)	26dB Occupied Bandwidth	Compliant
		99% Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.407 (a)(2)	RSS-210 (A9.2)	Conducted Transmitter Output Power	Compliant
Title 47 of the CFR, Part 15 §15.407 (a)(2)	RSS-210 (A8.2)	Power Spectral Density	Compliant
Title 47 of the CFR, Part 15 §15.407 (a)(6)		Peak Excursion	Not Applicable
Title 47 of the CFR, Part 15 §15.407 (b)(2), (3), (5), (6)	RSS-210 (A9.2)	Undesirable Emissions (15.205/15.209 - General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Compliant
Title 47 of the CFR, Part 15 §15.407(f)	RSS-102 (4.1)	RF Exposure	Compliant

Table 1. Executive Summary of EMC Part 15.407 ComplianceTesting

II. Equipment Configuration

A. Overview

MET Laboratories, Inc. was contracted by Roku to perform testing on the RC2X, under Roku's purchase order number 325443.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Roku RC2X.

The results obtained relate only to the item(s) tested.

Model(s) Tested:	RC2X	
Model(s) Covered:	RC2X	
EUT Specifications:	Primary Power: 3 VDC	
	FCC ID: TC2-RCB4	
	Type of Modulations:	OFDM, BPSK, QPSK, CCK, DSSS
	Equipment Code:	NII
	Peak RF Output Power:	-2.72 dBm
	EUT Frequency Ranges:	5180 MHz to 5240 MHz, 5745 MHz to 5825 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35º C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Andy Shen	
Report Date(s):	November 7, 2014	

Table 2. EUT Summary

B. References

CFR 47, Part 15, Subpart B	Electromagnetic Compatibility: Criteria for Radio Frequency Devices
CFR 47, Part 15, Subpart E	Unlicensed National Information Infrastructure Devices (UNII)
RSS-210, Issue 8, Dec. 2010	Low-power Licence-exempt Radiocommunications Devices (All Frequency Bands): Category I Equipment
RSS-GEN, Issue 3, Dec. 2010	General Requirements and Information for the Certification of Radio Apparatus
ICES-003, Issue 5 August 2012	Information Technology Equipment (ITE) — Limits and methods of measurement
ANSI C63.4:2003	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2009	American National Standard for Testing Unlicensed Wireless Devices

Table 3. References

C. Test Site

All testing was performed at MET Laboratories, Inc., 3162 Belick St., Santa Clara, CA 95054. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 10 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

D. Description of Test Sample

The Roku RC2X, Equipment Under Test (EUT), is a Remote Control. It will work with Roku Streaming Stick. It supports Wi-Fi 802.11a Channel 36 - 48. The remote shall operate from 2 x AAA Alkaline batteries. Power requirements shall be a maximum operating voltage of 3.3 Volts. The power will not be regulated.

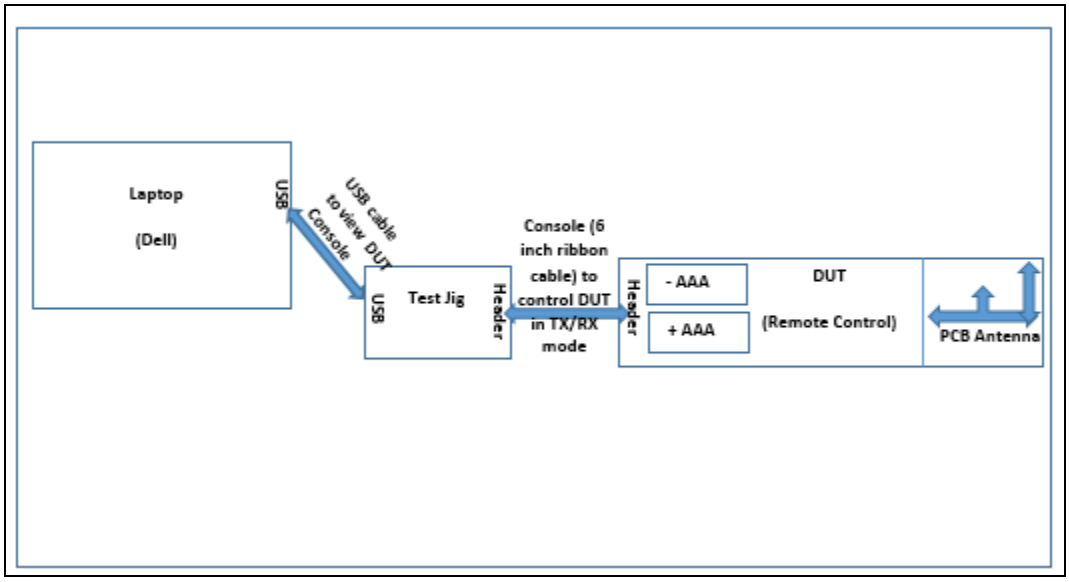


Figure 1. Block Diagram of Test Configuration

E. Equipment Configuration

Ref. ID	Name / Description	Model Number	Part Number	Serial Number	Revision
1	N/A	Roku Wi-Fi Remote Control	RC2X	3226000088	N/A
2	N/A	Roku Wi-Fi Remote Control	RC2X	3226000090	14092531

Table 4. Equipment Configuration

F. Support Equipment

Ref. ID	Name / Description	Manufacturer	Model Number
1	Test Jig	Atmel	210920-10
2	Dell Lap top	Dell	Latitude E6410
3	Ribbon Cable	Atmel	N/A

Table 5. Support Equipment

G. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Description	Qty.	Length (m)	Shielded (Y/N)	Termination Point
1	Micro USB-to-USB	Computer Cable	1	1	No	N/A
2	Lap top Charger	Dell AC Adapter	1	1	No	(AC 100 -240 V/50 – 60 Hz)

Table 6. Ports and Cabling Information

H. Mode of Operation

FW is running on the DUT (Remote Control) and through console we can configure DUT into different Wi-Fi channels.

I. Method of Monitoring EUT Operation

A Spectrum Analyzer and a Power Meter was use to monitor the EUT's transmitter channel and power output.

J. Modifications

a) Modifications to EUT

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the test standard.

K. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Roku upon completion of testing.

III. Electromagnetic Compatibility Criteria for Unintentional Radiators

Electromagnetic Compatibility Criteria

§ 15.107 Conducted Emissions Limits

Test Requirement(s):

15.107 (a) Except for Class A digital devices, for equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in Table 7. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals.

15.107 (b) For a Class A digital device that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in Table 7. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals. The lower limit applies at the band edges.

Frequency range (MHz)	Class A Conducted Limits (dBµV)		*Class B Conducted Limits (dBµV)	
	Quasi-Peak	Average	Quasi-Peak	Average
* 0.15- 0.45	79	66	66 - 56	56 - 46
0.45 - 0.5	79	66	56	46
0.5 - 30	73	60	60	50
Note 1 — The lower limit shall apply at the transition frequencies. Note 2 — The limit decreases linearly with the logarithm if the frequency in the range 0.15 MHz to 0.5 MHz.				

Table 7. Conducted Limits for Radio Frequency Devices calculated from FCC Part 15 Subsections 15.107(a) (b)

Test Results: The EUT was not applicable with the Class B requirement(s) of this section.

Radiated Emission Limits

§ 15.109 Radiated Emissions Limits

Test Requirement(s): **15.109 (a)** Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the Class B limits expressed in Table 8.

15.109 (b) The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the Class A limits expressed in Table 8.

Frequency (MHz)	Field Strength (dBµV/m)	
	§15.109 (b), Class A Limit (dBµV) @ 10m	§15.109 (a),Class B Limit (dBµV) @ 3m
30 - 88	39.00	40.00
88 - 216	43.50	43.50
216 - 960	46.40	46.00
Above 960	49.50	54.00

Table 8. Radiated Emissions Limits calculated from FCC Part 15, §15.109 (a) (b)

Test Procedures: The EUT was placed on a non-metallic table, 80 cm above the ground plane inside a semi-anechoic chamber. The method of testing and test conditions of ANSI C63.4 were used. An antenna was located 10m from the EUT on an adjustable mast. A pre-scan was first performed in order to find prominent radiated emissions. For final emissions measurements at each frequency of interest, the EUT was rotated and the antenna height was varied between 1 m and 4 m in order to maximize the emission. Measurements in both horizontal and vertical polarities were made and the data was recorded. Unless otherwise specified, measurements were made using a quasi-peak detector with a 120 kHz bandwidth.

Test Results: The EUT was compliant with the Class B requirement(s) of this section. Measured emissions were below applicable limits.

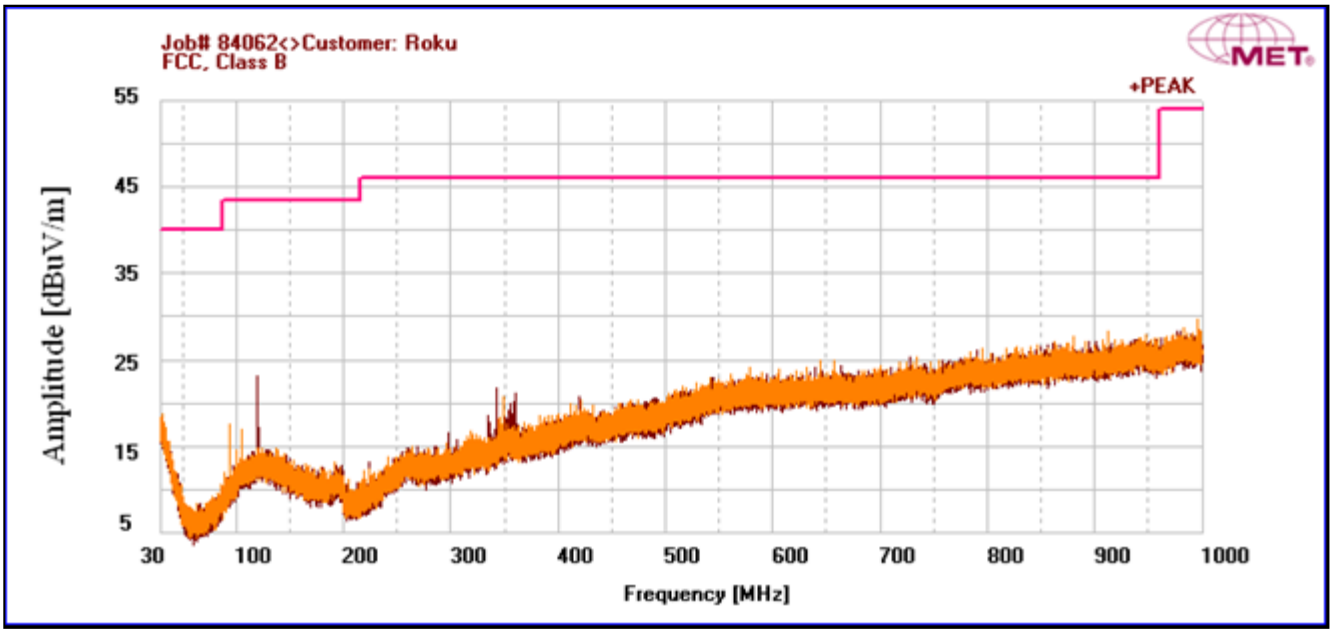
Test Engineer(s): Andy Shen

Test Date(s): 11/03/14

Radiated Emissions Limits Test Results, Class B

Frequency (MHz)	Antenna Polarity	EUT Azimuth (Degrees)	Antenna Height (cm)	Uncorrected Amplitude (dBµV)	ACF (dB/m)	Pre Amp Gain (dB)	CBL (dB)	DCF (dB)	Corrected Amplitude (dBµV/m)	Limit (dBµV/m)	Margin (dB)
943.7	V	94	150.76	0.43	21.257	0	5.606	0	27.293	46	-18.707
913.2	V	0	100	0.22	20.577	0	5.534	0	26.331	46	-19.669
343.32	V	197	100	6.72	14.083	0	3.338	0	24.141	46	-21.859
423.48	H	0	131.58	1.49	16.349	0	3.697	0	21.536	46	-24.464
876.04	H	0	100	0.2	20.729	0	5.427	0	26.356	46	-19.644
670.28	H	274	183.11	-1.15	18.84	0	4.779	0	22.469	46	-23.531

Table 9. Radiated Emissions Limits, Test Results, 30 MHz – 1 GHz



Plot 1. Radiated Emissions, 30 MHz - 1 GHz

IV. Electromagnetic Compatibility Criteria for Intentional Radiators

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement: **§ 15.203:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

a.) Antenna must be permanently attached to the unit.

b.) Antenna must use a unique type of connector to attach to the EUT.

c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results: The EUT as tested is compliant the criteria of §15.203.

Test Engineer(s): Andy Shen

Test Date(s): 10/27/14

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.207 Conducted Emissions Limits

Test Requirement(s): **§ 15.207 (a):** For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 Σ line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	§ 15.207(a), Conducted Limit (dBμV)	
	Quasi-Peak	Average
* 0.15- 0.45	66 - 56	56 - 46
0.45 - 0.5	56	46
0.5 - 30	60	50

Table 10. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)

Test Results: The EUT was not applicable with this requirement.

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15. 403(c) 26dB Bandwidth

Test Requirements: **§ 15.403 (i):** For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

Test Procedure: The transmitter was set to both operating frequencies at the highest output power and connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately equal to 1% of the total emission bandwidth, VBW > RBW. The 26 dB Bandwidth was measured and recorded.

Test Results The 26 dB Bandwidth was compliant with the requirements of this section and was determined from the plots on the following pages.

Test Engineer(s): Andy Shen

Test Date(s): 10/28/14

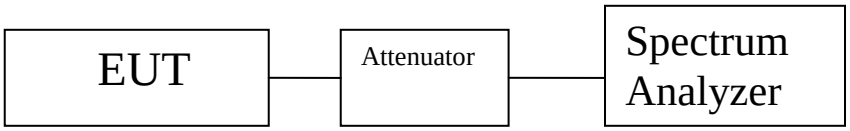
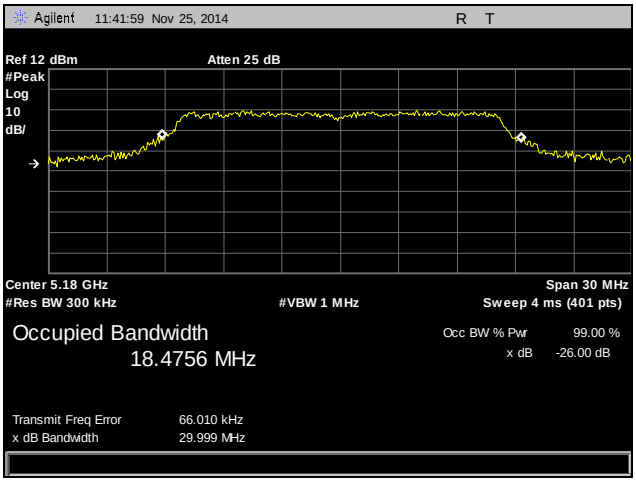
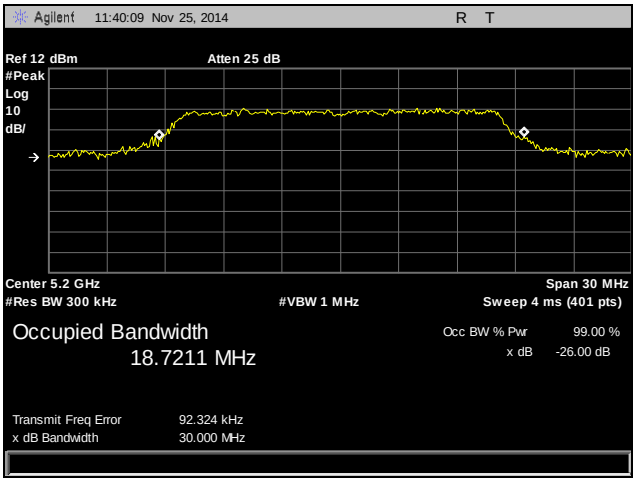


Figure 2. Occupied Bandwidth, Test Setup

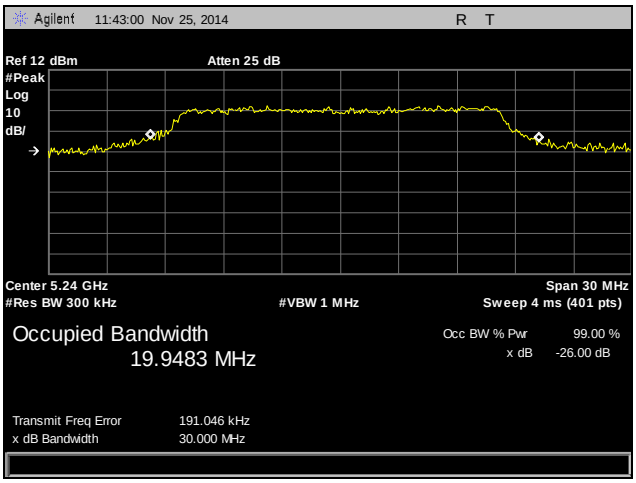
Occupied Bandwidth Test Results, 802.11a



Plot 2. Occupied Bandwidth, Low Channel, 5180 MHz, 802.11a

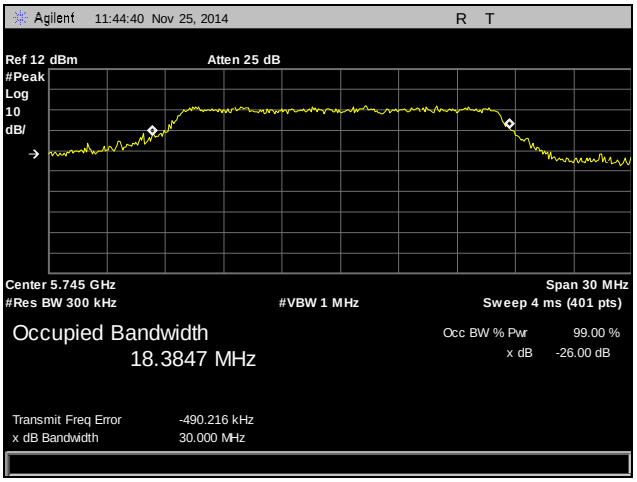


Plot 3. Occupied Bandwidth, Mid Channel, 5200 MHz, 802.11a

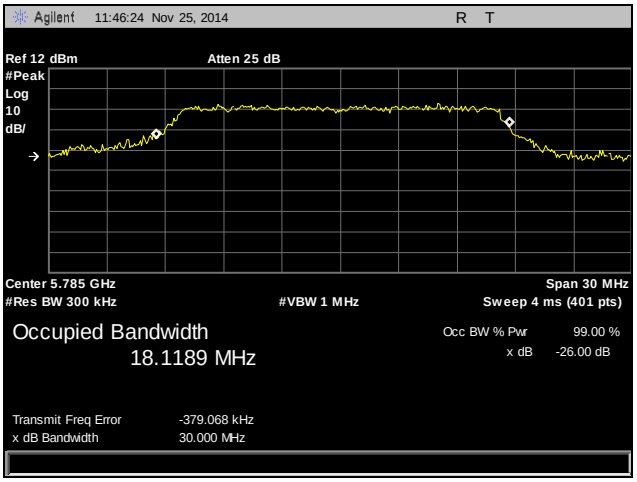


Plot 4. Occupied Bandwidth, High Channel, 5240 MHz, 802.11a

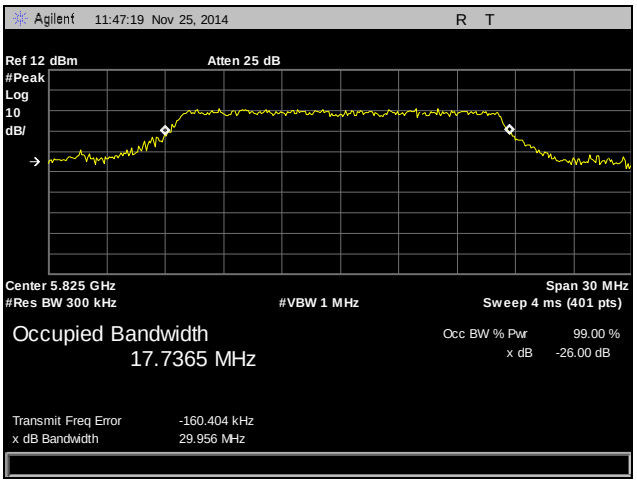
Occupied Bandwidth Test Results, 802.11a



Plot 5. Occupied Bandwidth, Low Channel, 5745 MHz, 802.11a



Plot 6. Occupied Bandwidth, Mid Channel, 5785 MHz, 802.11a



Plot 7. Occupied Bandwidth, High Channel, 5825 MHz, 802.11a

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15. 407(a)(1) RF Power Output

Test Requirements: **§15.407(a)(1):** For the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 30dBm.

Test Procedure: The EUT was connected to a spectrum analyzer through an RF cable and an attenuator. The EUT was set to transmit on low, mid, and high channels and the power was measured according to method SA-1 from FCC Publication Number 789033. Power across the antenna ports was summed. Power setting spw 0 was use for testing.

Test Results: Equipment was compliant with the Peak Power Output limits of **§ 15.401(a)(1)**.

Test Engineer(s): Andy Shen

Test Date(s): 10/28/14

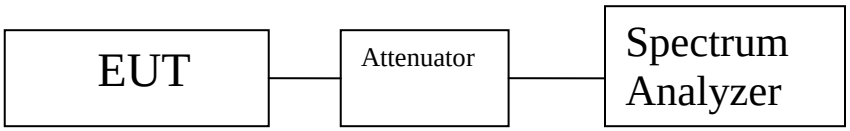
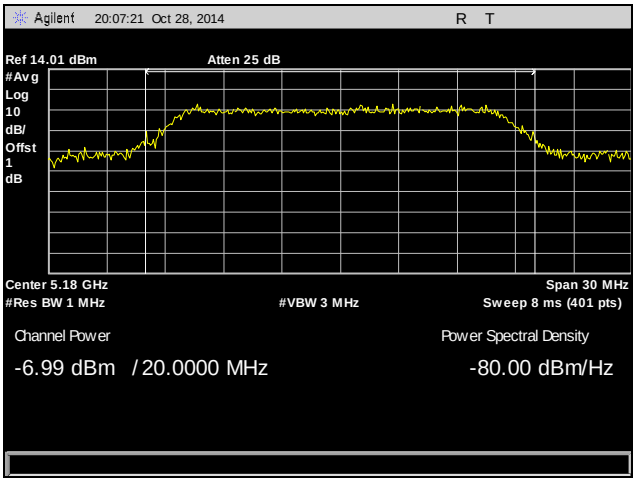
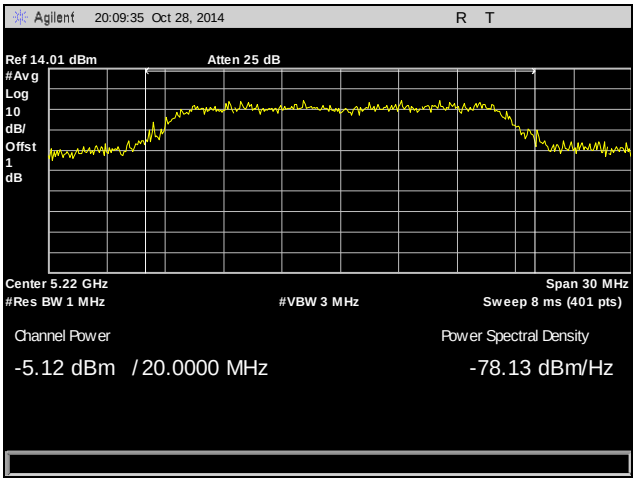


Figure 3. Power Output Test Setup

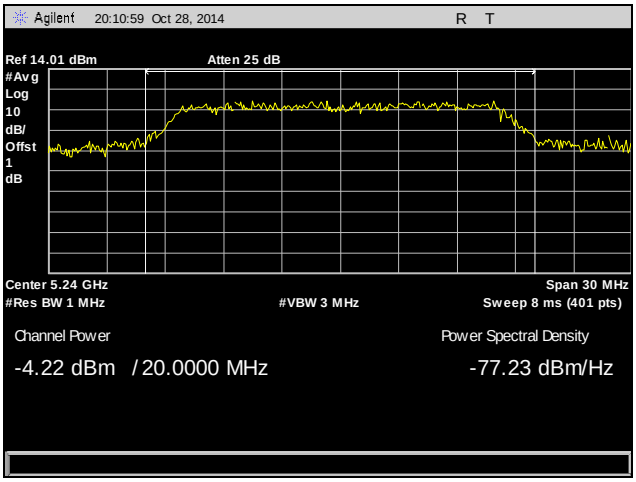
Peak Power Output Test Results, 802.11a



Plot 8. Peak Power Output, Low Channel, 5180 MHz, 802.11a

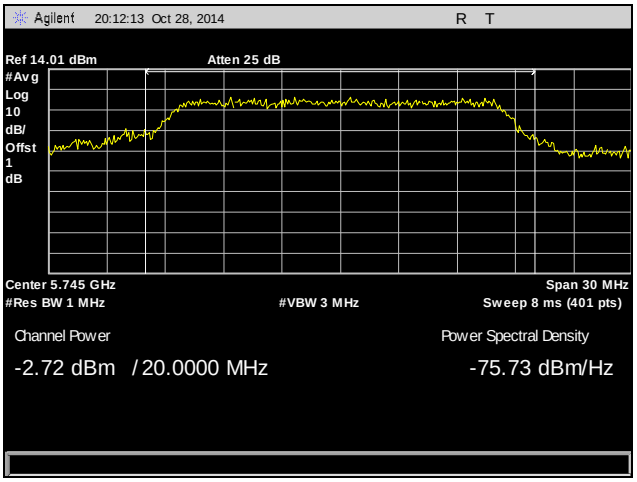


Plot 9. Peak Power Output, Mid Channel, 5220 MHz, 802.11a

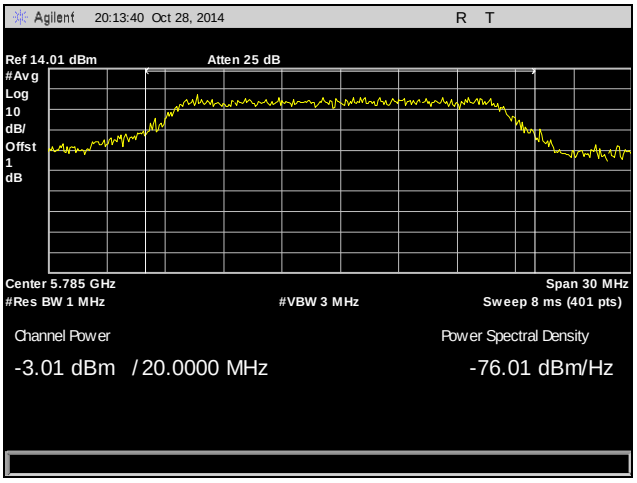


Plot 10. Peak Power Output, High Channel, 5240 MHz, 802.11a

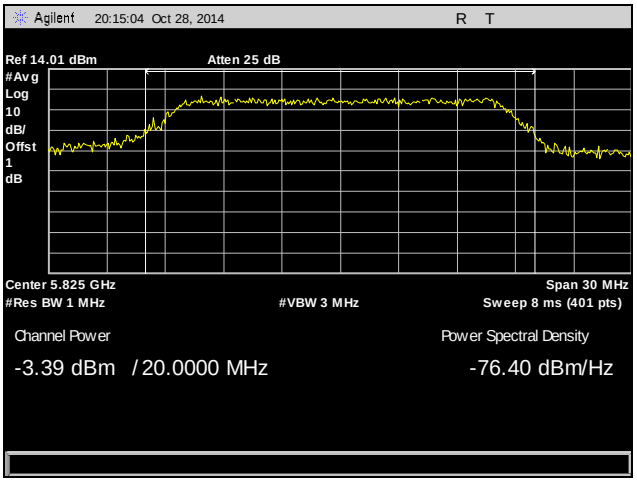
Peak Power Output Test Results, 802.11a



Plot 11. Peak Power Output, Low Channel, 5745 MHz, 802.11a



Plot 12. Peak Power Output, Mid Channel, 5785 MHz, 802.11a



Plot 13. Peak Power Output, High Channel, 5825 MHz, 802.11a

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(a)(2) Peak Power Spectral Density

Test Requirements: **§ 15.407(a)(2):** In addition, the peak power spectral density shall not exceed 17 dBm in any 1 megahertz band.

Test Procedure: The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level on the EUT. The RBW was set to 1MHz and the VBW was set to 3MHz. The method of measurement #2 from the FCC Public Notice DA 02-2138 was used.

Test Results: Equipment was compliant with the peak power spectral density limits of **§ 15.407 (a)(2).** The peak power spectral density was determined from plots on the following page(s).

Test Engineer(s): Andy Shen

Test Date(s): 10/30/14

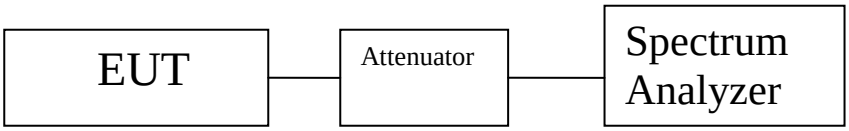
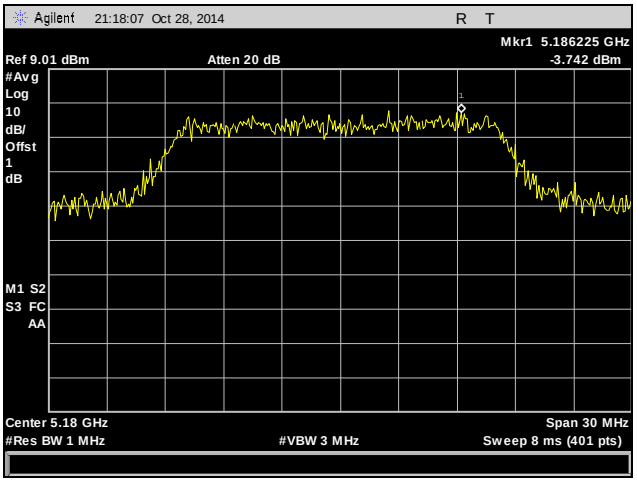
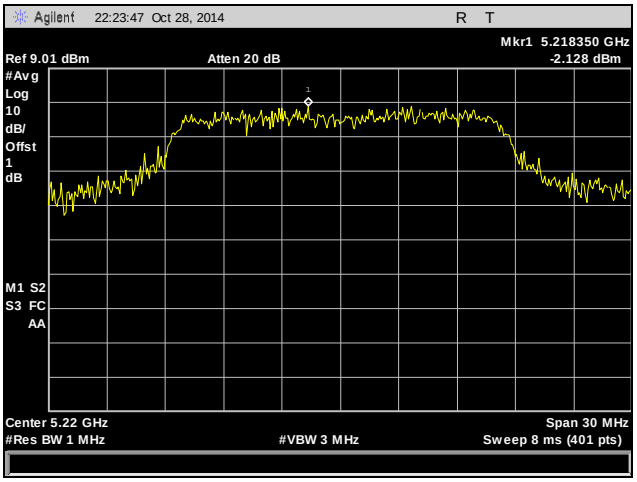


Figure 4. Power Spectral Density Test Setup

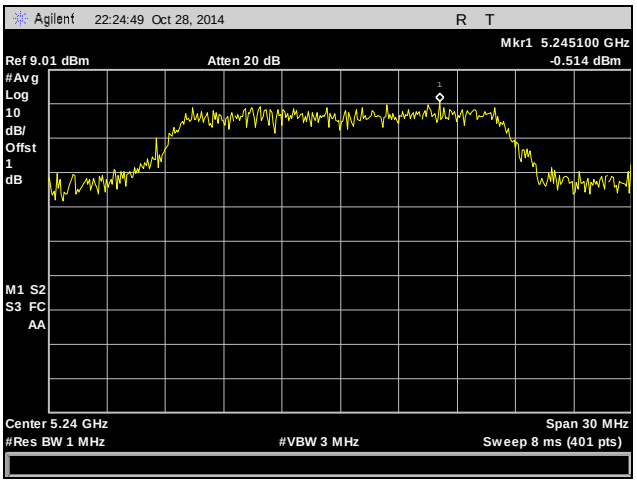
Peak Power Spectral Density, 802.11a



Plot 14. Peak Power Spectral Density, Low Channel, 5180 MHz, 802.11a

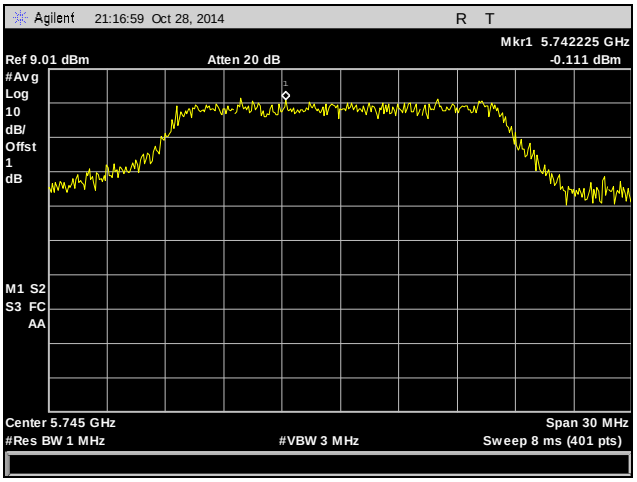


Plot 15. Peak Power Spectral Density, Mid Channel, 5220 MHz, 802.11a

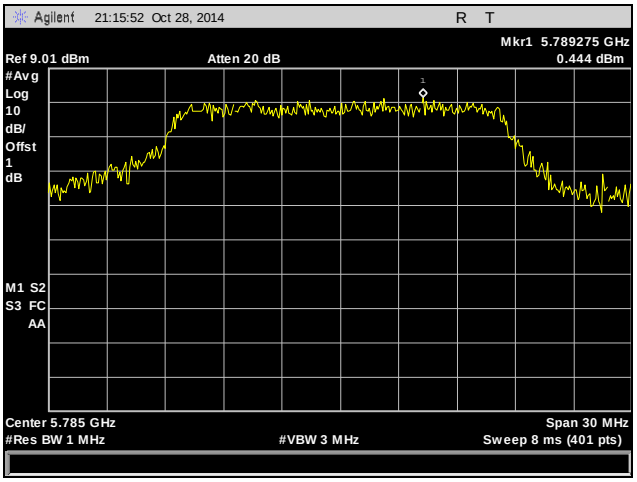


Plot 16. Peak Power Spectral Density, High Channel, 5240 MHz, 802.11a

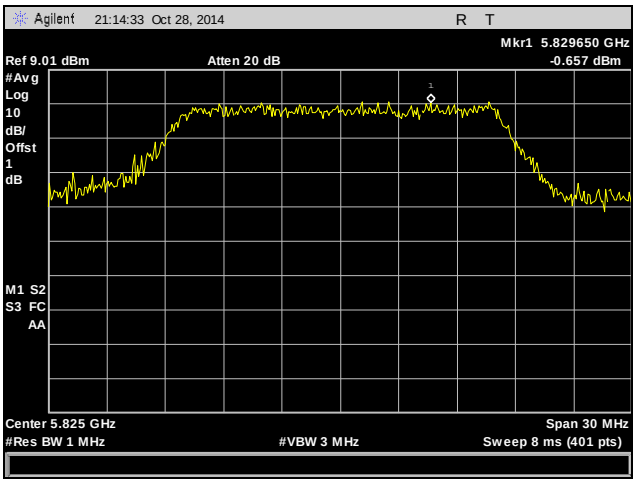
Peak Power Spectral Density, 802.11a



Plot 17. Peak Power Spectral Density, Low Channel, 5745 MHz, 802.11a



Plot 18. Peak Power Spectral Density, Mid Channel, 5785 MHz, 802.11a



Plot 19. Peak Power Spectral Density, High Channel, 5825 MHz, 802.11a

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(b)(1), (6), (7) Undesirable Emissions

Test Requirements: **§ 15.407(b)(1), (6), (7)**; **§15.205:** Emissions outside the frequency band.

§ 15.407(b)(1): For transmitters operating in the 5.15-5.25 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz.

§ 15.407(b)(6): Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in Section 15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in Section 15.207.

§ 15.407(b)(7): The provisions of Section 15.205 of this part apply to intentional radiators operating under this section.

Test Procedure: The EUT was placed on a non-conducting 0.8m high stand on a turntable in a semi-anechoic chamber. The EUT was set to transmit on low, mid, and high channels, while the turntable was rotated 360 degrees through three orthogonal axes and the receiving antenna height was varied to maximize emissions.

For frequencies from 30MHz to 1GHz, measurements were first made using a peak detector with a 100kHz resolution bandwidth. Emissions which exceeded the limits were re-measured using a quasi-peak detector with a 120 kHz resolution bandwidth.

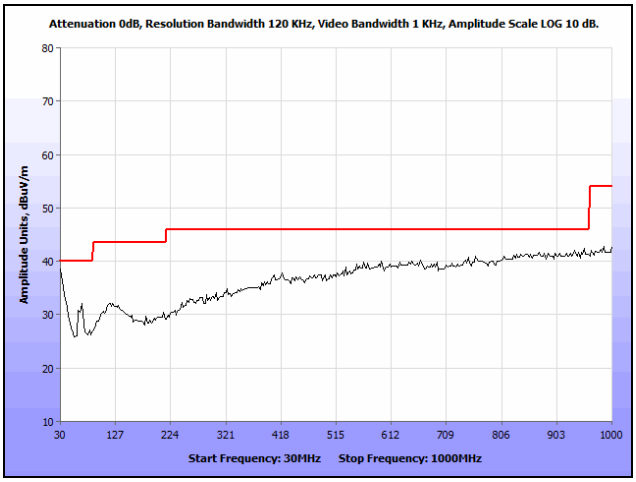
For measurements above 1 GHz, measurements were made with a Peak detector with 1 MHz resolution bandwidth. Where the spurious emissions fell into a restricted band, measurements were also made with an average detector to make sure they complied with 15.209 limits.
Only noise floor was measured above 18 GHz.

Test Results: The EUT was compliant with the Radiated Emission limits for Intentional Radiators. See following pages for detailed test results.

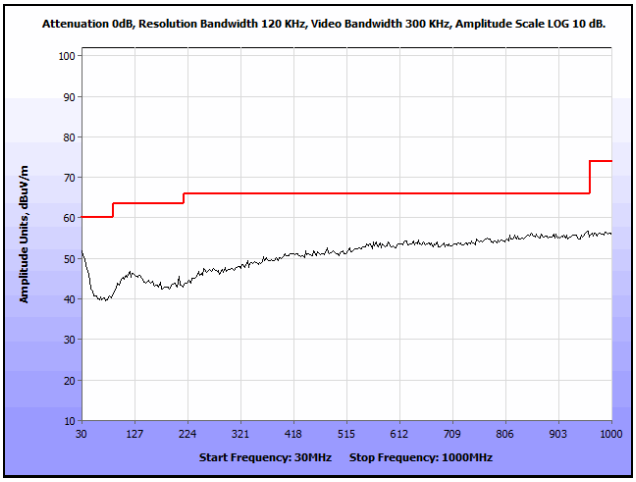
Test Engineer(s): Andy Shen

Test Date(s): 10/30/14

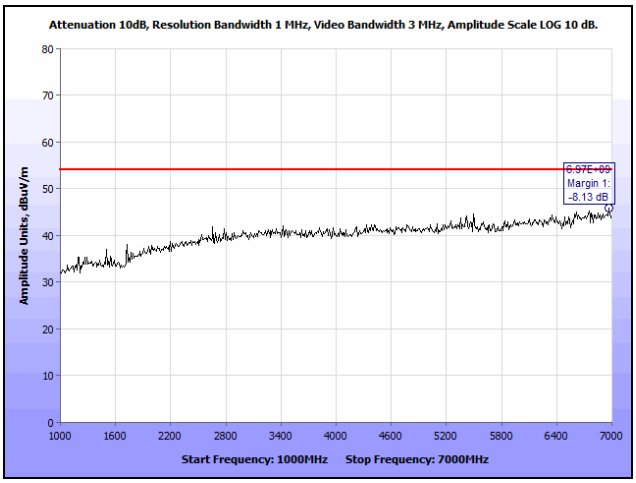
Radiated Spurious Emissions Test Results, 802.11a



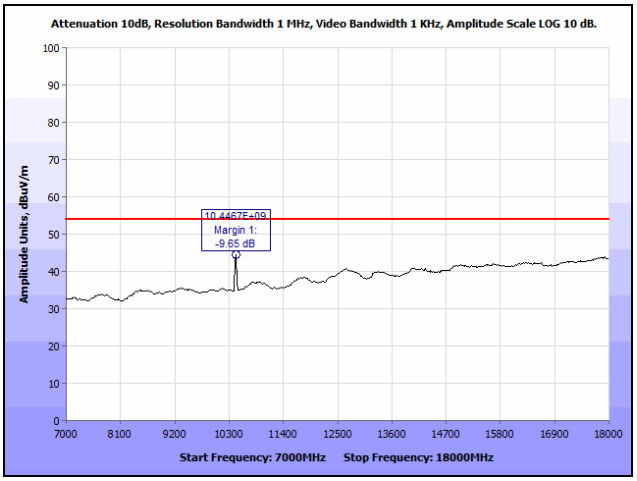
Plot 20. Radiated Spurious Emissions, Low Channel, 5180 MHz, 802.11a, 30 MHz – 1 GHz, Average



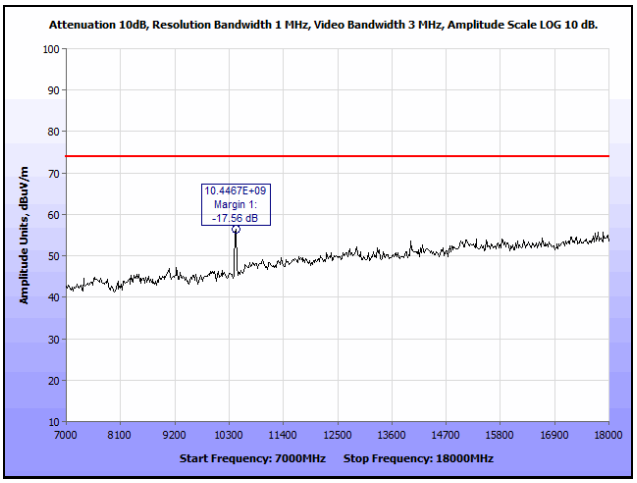
Plot 21. Radiated Spurious Emissions, Low Channel, 5180 MHz, 802.11a, 30 MHz – 1 GHz, Peak



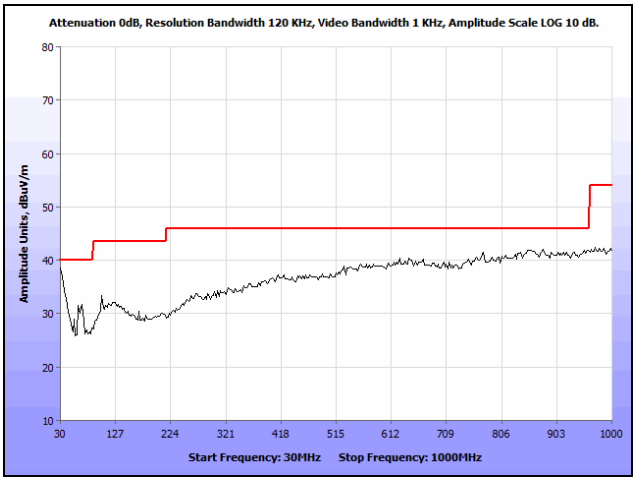
Plot 22. Radiated Spurious Emissions, Low Channel, 5180 MHz, 802.11a, 1 GHz – 7 GHz, Average



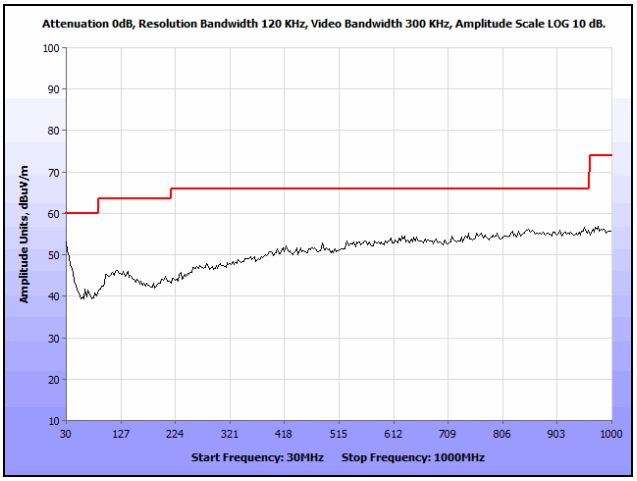
Plot 23. Radiated Spurious Emissions, Low Channel, 5180 MHz, 802.11a, 7 GHz – 18 GHz, Average



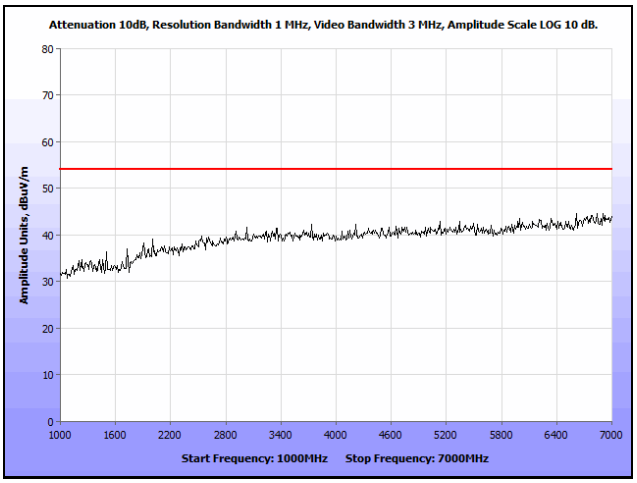
Plot 24. Radiated Spurious Emissions, Low Channel, 5180 MHz, 802.11a, 7 GHz – 18 GHz, Peak



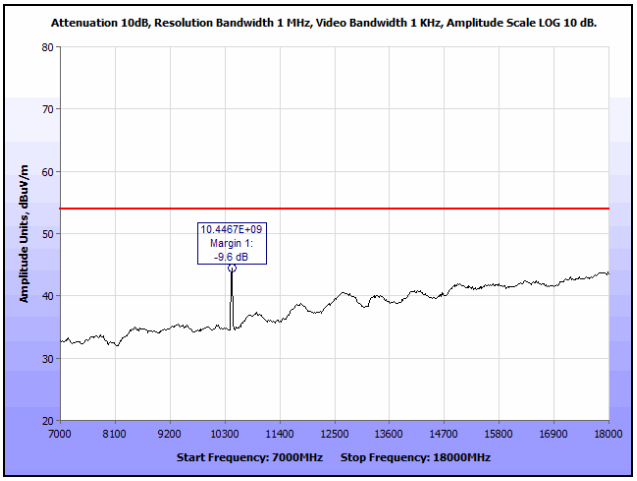
Plot 25. Radiated Spurious Emissions, Mid Channel, 5220 MHz, 802.11a, 30 MHz – 1 GHz, Average



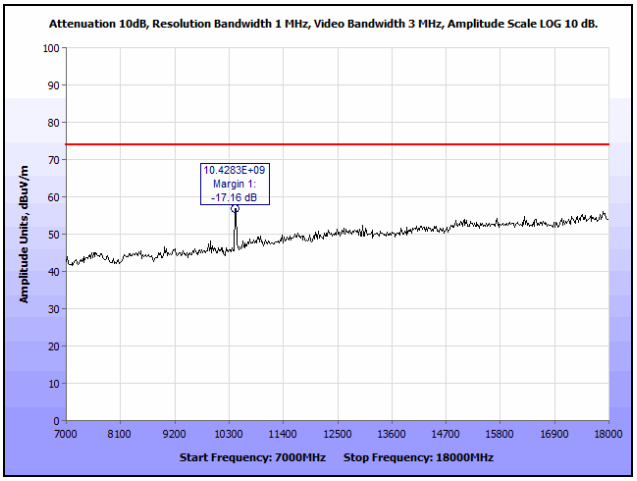
Plot 26. Radiated Spurious Emissions, Mid Channel, 5220 MHz, 802.11a, 30 MHz – 1 GHz, Peak



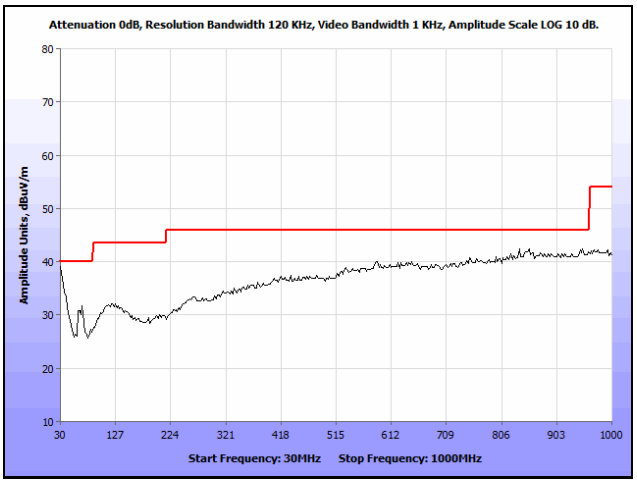
Plot 27. Radiated Spurious Emissions, Mid Channel, 5220 MHz, 802.11a, 1 GHz – 7 GHz, Average



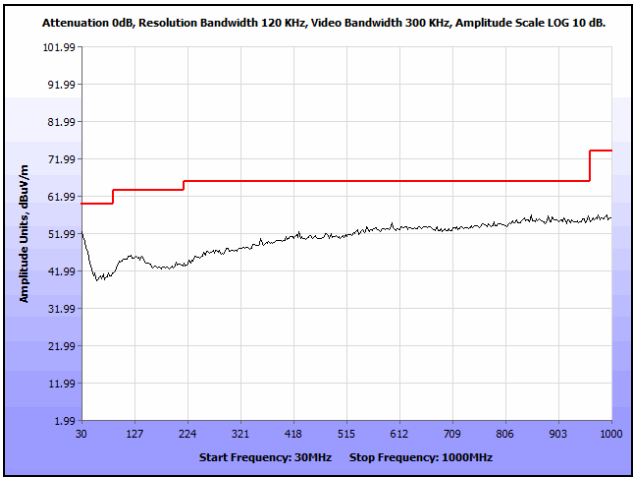
Plot 28. Radiated Spurious Emissions, Mid Channel, 5220 MHz, 802.11a, 7 GHz – 18 GHz, Average



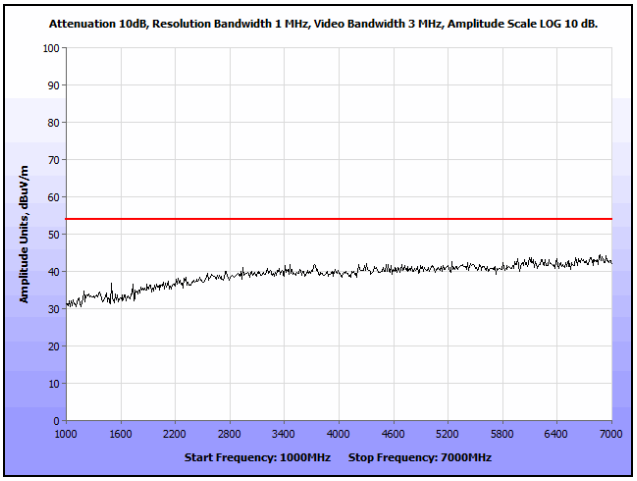
Plot 29. Radiated Spurious Emissions, Mid Channel, 5220 MHz, 802.11a, 7 GHz – 18 GHz, Peak



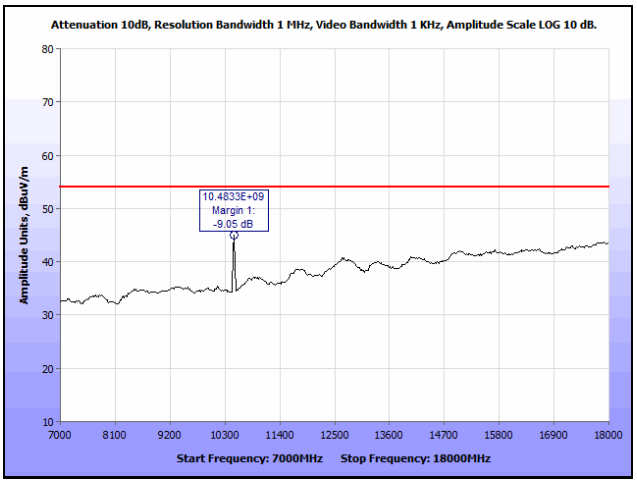
Plot 30. Radiated Spurious Emissions, High Channel, 5240 MHz, 802.11a, 30 MHz – 1 GHz, Average



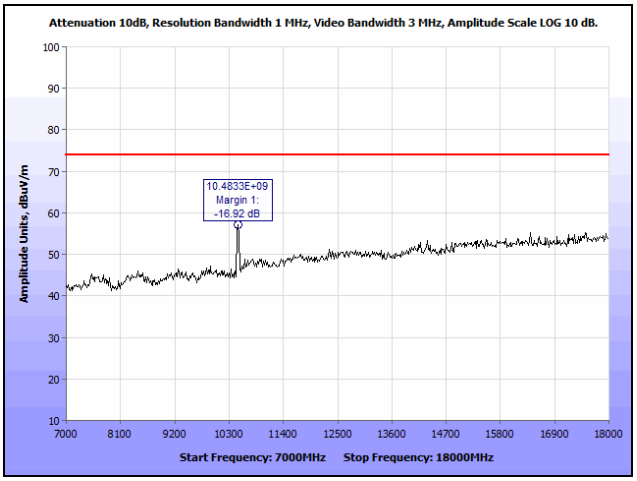
Plot 31. Radiated Spurious Emissions, High Channel, 5240 MHz, 802.11a, 30 MHz – 1 GHz, Peak



Plot 32. Radiated Spurious Emissions, High Channel, 5240 MHz, 802.11a, 1 GHz – 7 GHz, Average

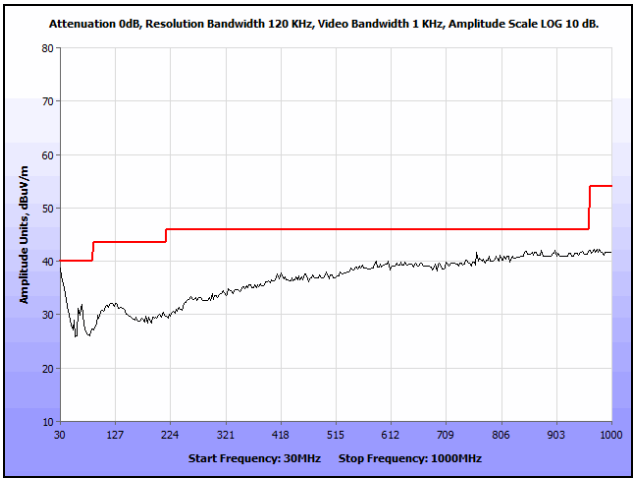


Plot 33. Radiated Spurious Emissions, High Channel, 5240 MHz, 802.11a, 7 GHz – 18 GHz, Average

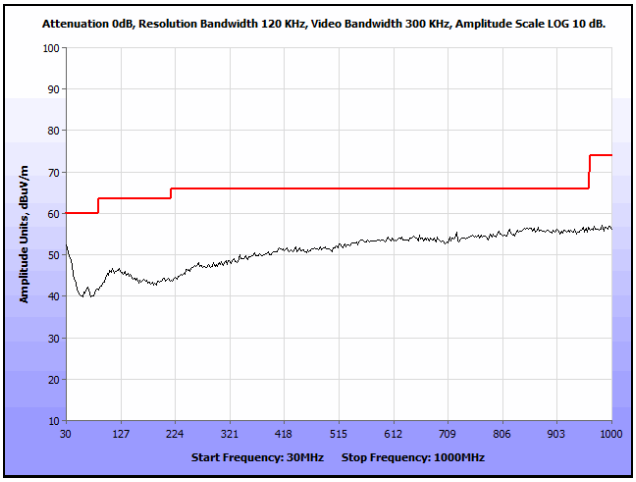


Plot 34. Radiated Spurious Emissions, High Channel, 5240 MHz, 802.11a, 7 GHz – 18 GHz, Peak

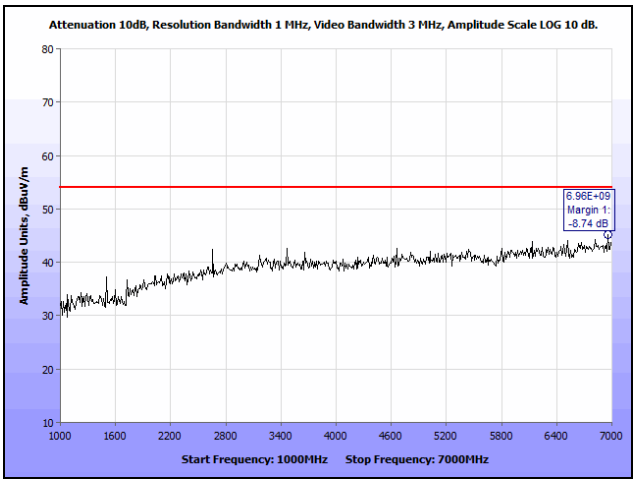
Radiated Spurious Emissions Test Results, 802.11a



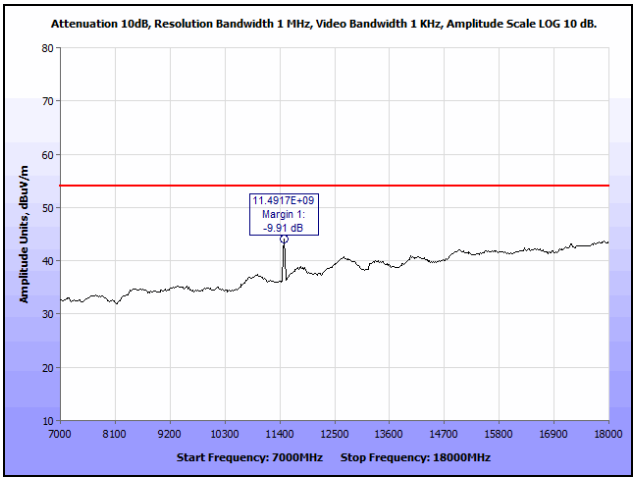
Plot 35. Radiated Spurious Emissions, Low Channel, 5745 MHz, 802.11a, 30 MHz – 1 GHz, Average



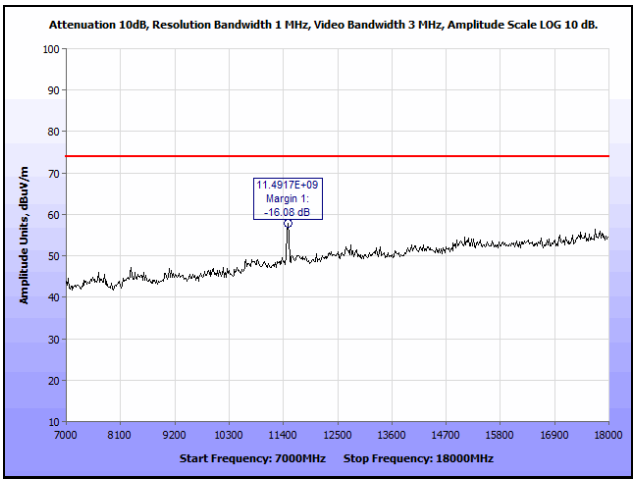
Plot 36. Radiated Spurious Emissions, Low Channel, 5745 MHz, 802.11a, 30 MHz – 1 GHz, Peak



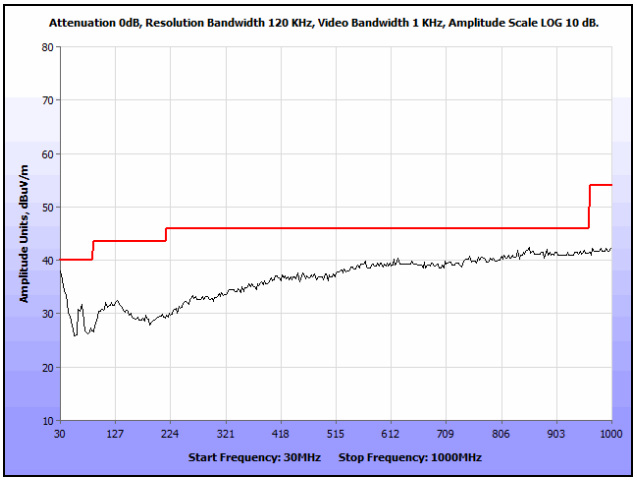
Plot 37. Radiated Spurious Emissions, Low Channel, 5745 MHz, 802.11a, 1 GHz – 7 GHz, Average



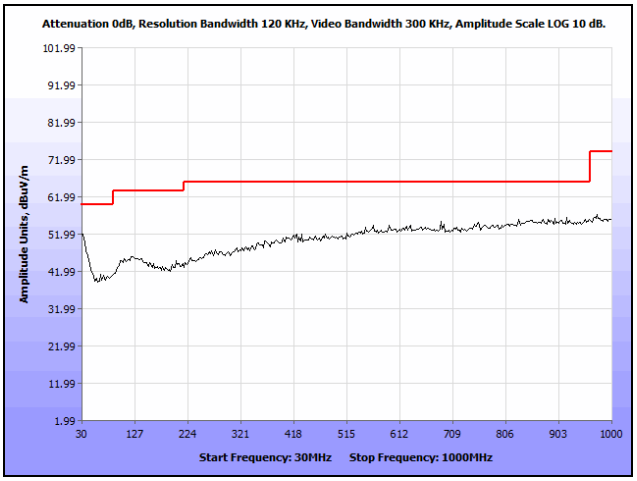
Plot 38. Radiated Spurious Emissions, Low Channel, 5745 MHz, 802.11a, 7 GHz – 18 GHz, Average



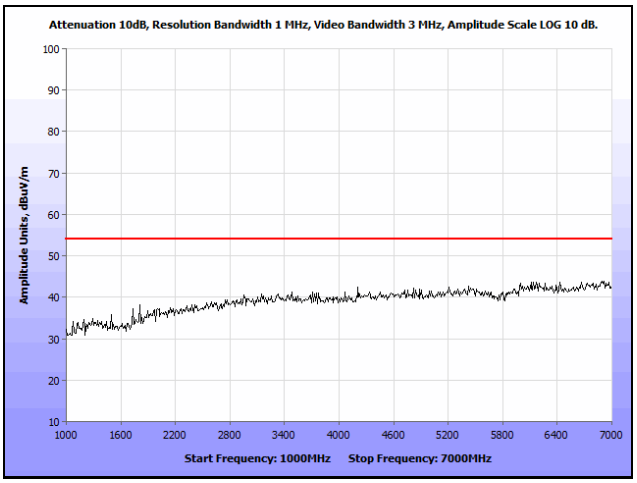
Plot 39. Radiated Spurious Emissions, Low Channel, 5745 MHz, 802.11a, 7 GHz – 18 GHz, Peak



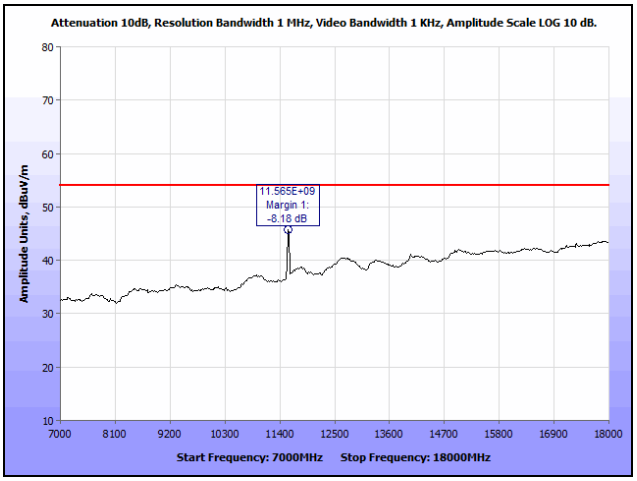
Plot 40. Radiated Spurious Emissions, Mid Channel, 5785 MHz, 802.11a, 30 MHz – 1 GHz, Average



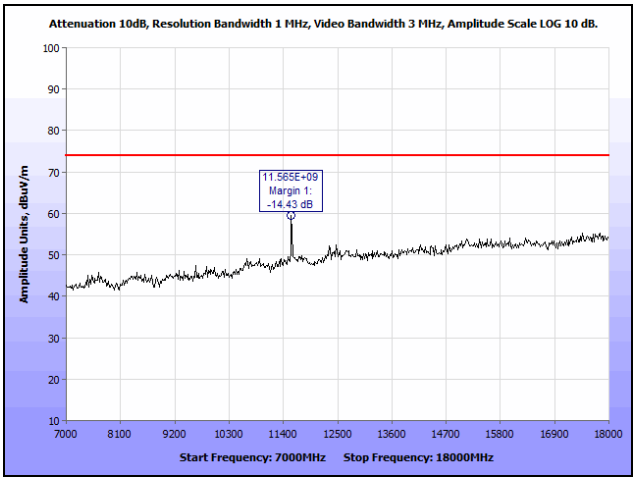
Plot 41. Radiated Spurious Emissions, Mid Channel, 5785 MHz, 802.11a, 30 MHz – 1 GHz, Peak



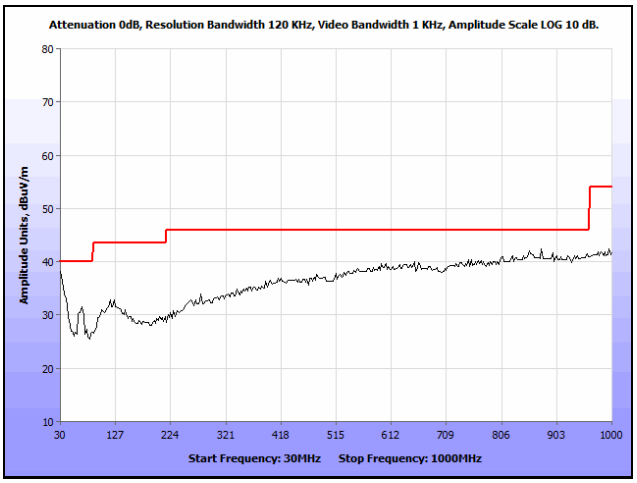
Plot 42. Radiated Spurious Emissions, Mid Channel, 5785 MHz, 802.11a, 1 GHz – 7 GHz, Average



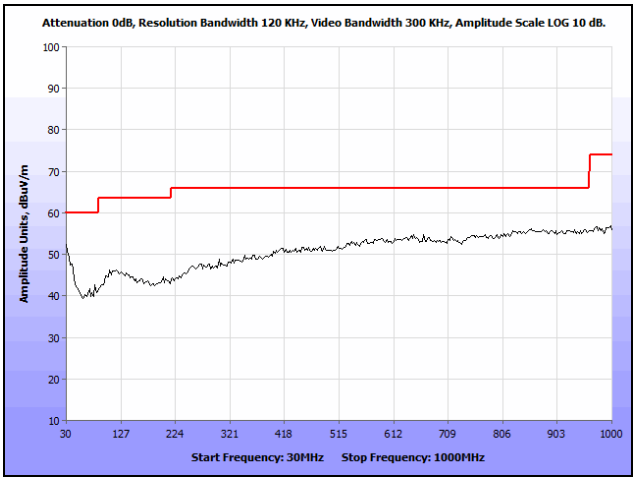
Plot 43. Radiated Spurious Emissions, Mid Channel, 5785 MHz, 802.11a, 7 GHz – 18 GHz, Average



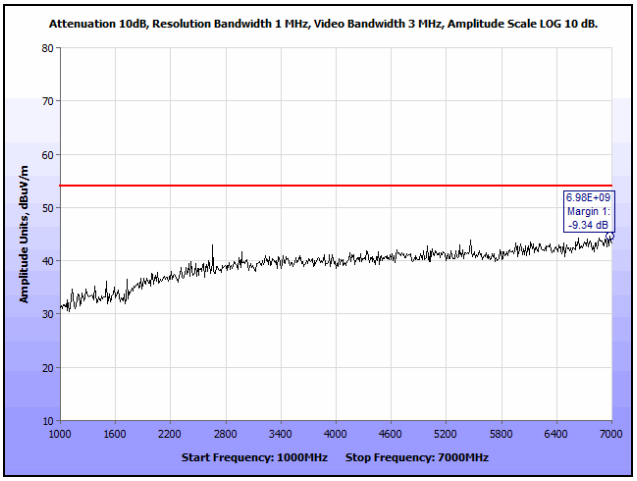
Plot 44. Radiated Spurious Emissions, Mid Channel, 5785 MHz, 802.11a, 7 GHz – 18 GHz, Peak



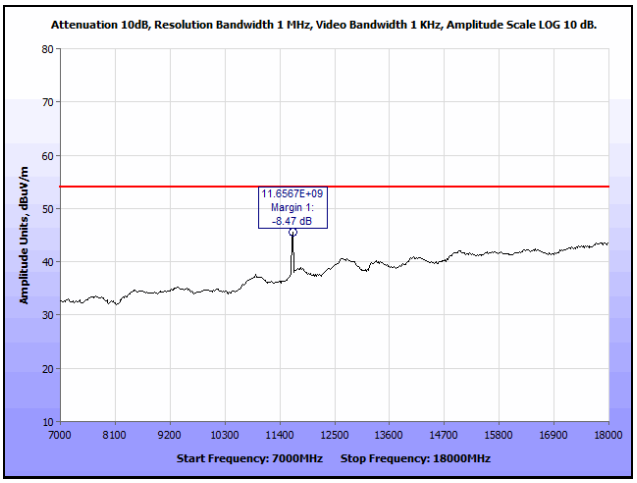
Plot 45. Radiated Spurious Emissions, High Channel, 5825 MHz, 802.11a, 30 MHz – 1 GHz, Average



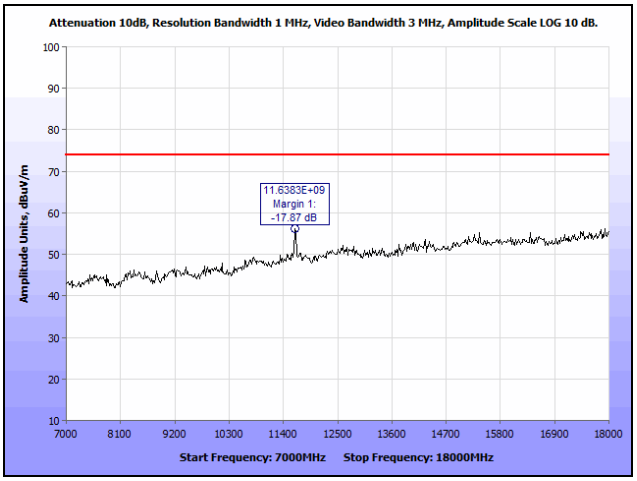
Plot 46. Radiated Spurious Emissions, High Channel, 5825 MHz, 802.11a, 30 MHz – 1 GHz, Peak



Plot 47. Radiated Spurious Emissions, High Channel, 5825 MHz, 802.11a, 1 GHz – 7 GHz, Average



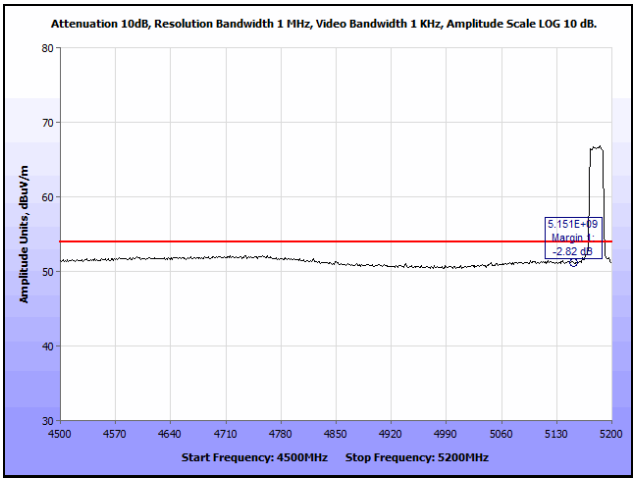
Plot 48. Radiated Spurious Emissions, High Channel, 5825 MHz, 802.11a, 7 GHz – 18 GHz, Average



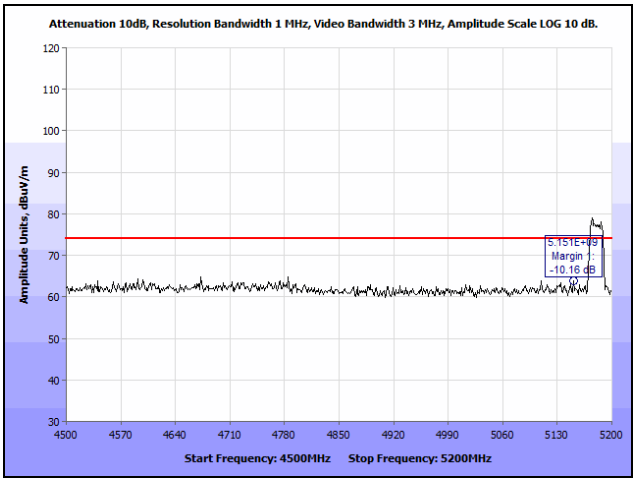
Plot 49. Radiated Spurious Emissions, High Channel, 5825 MHz, 802.11a, 7 GHz – 18 GHz, Peak

Radiated Band Edge Measurements

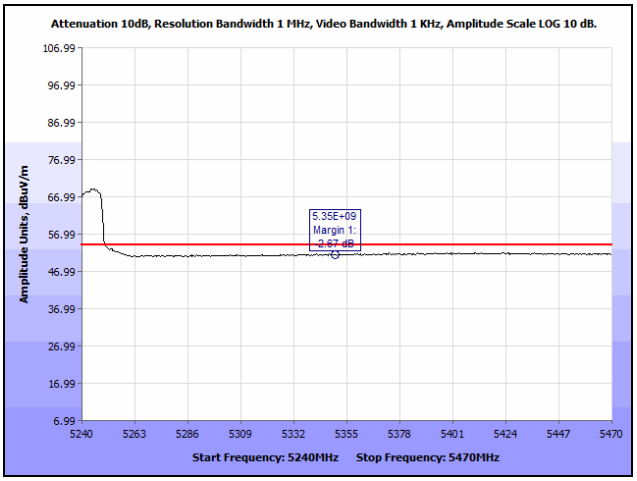
Test Procedures: The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.



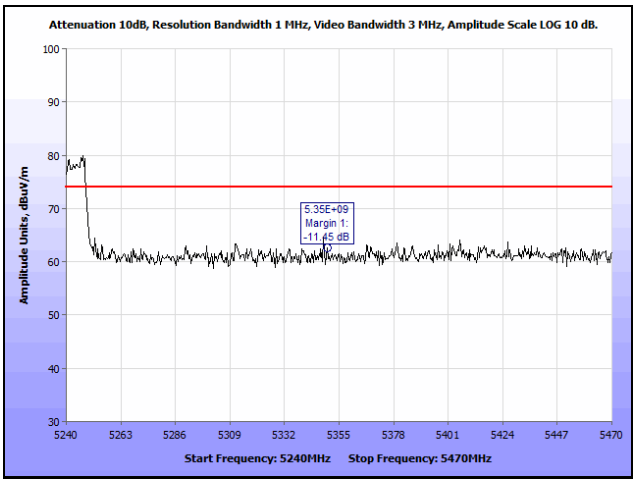
Plot 50. Radiated Band Edge, 802.11a, 5180 MHz, Low Channel, Average



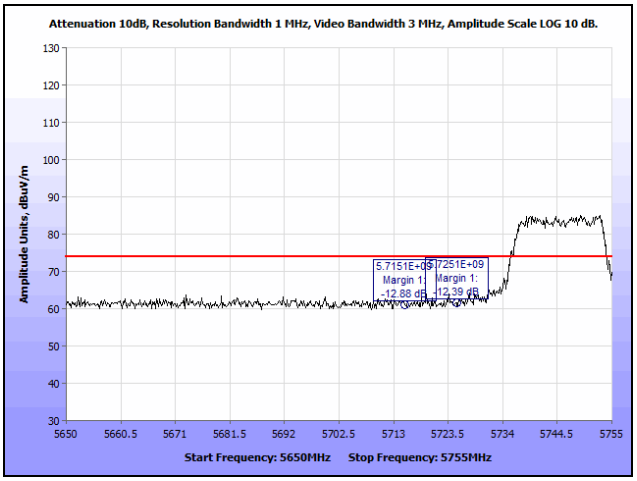
Plot 51. Radiated Band Edge, 802.11a, 5180 MHz, Low Channel, Peak



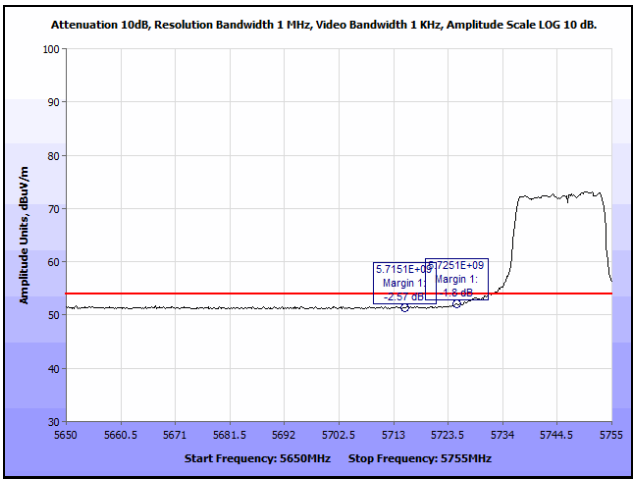
Plot 52. Radiated Band Edge, 802.11a, 5240 MHz, High Channel, Average



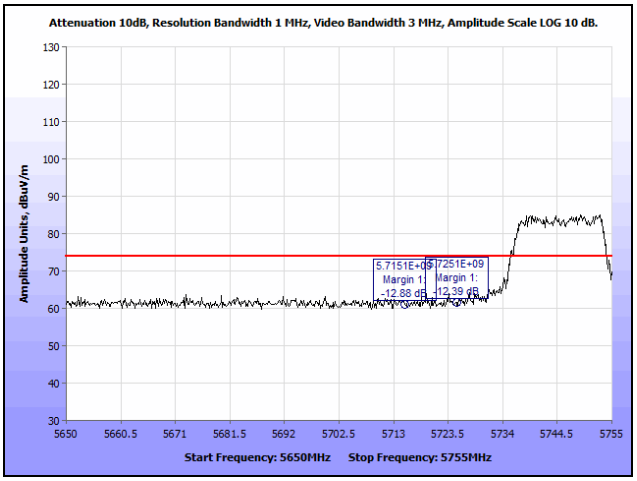
Plot 53. Radiated Band Edge, 802.11a, 5240 MHz, High Channel, Peak



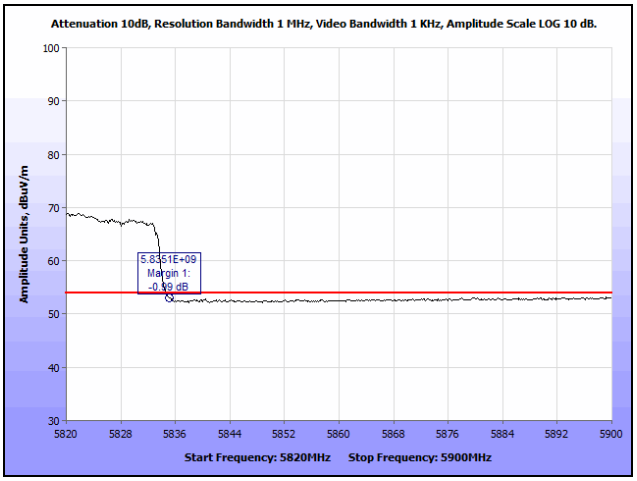
Plot 54. Radiated Band Edge, 802.11a, 5745 MHz, Low Channel, Average @ 5725 & 5715



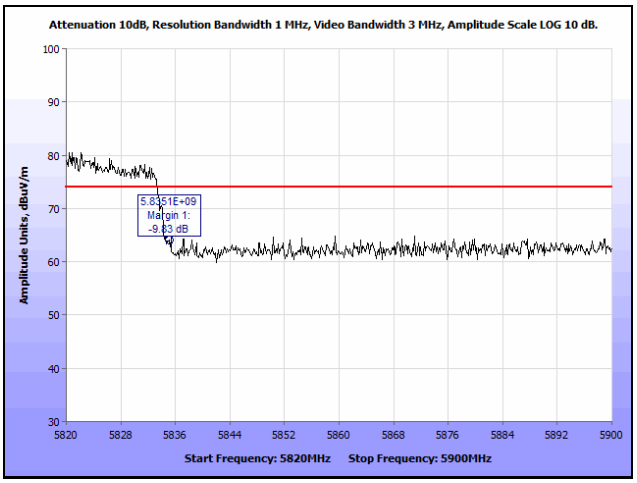
Plot 55. Radiated Band Edge, 802.11a, 5745 MHz, Low Channel, Average @ BandEdge 5725 MHz & 5715 MHz



Plot 56. Radiated Band Edge, 802.11a, 5745 MHz, Low Channel, Peak @ BandEdge 5725 MHz & 5715 MHz



Plot 57. Radiated Band Edge, 802.11a, 5825 MHz, High Channel, Average @ BandEdge 5835 MHz



Plot 58. Radiated Band Edge, 802.11a, 5825 MHz, High Channel, Peak @ BandEdge 5835 MHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(f) RF Exposure

RF Exposure Requirements: **§1.1307(b)(1) and §1.1307(b)(2):** Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

RF Radiation Exposure Limit: **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

MPE Limit Calculation: EUT's operating frequency is 5180 MHz to 5240 MHz, 5745 MHz to 5825 MHz;. Highest conducted power = 0.527 mW (i.e. -2.72 dBm).
Therefore, **Limit for Uncontrolled exposure: 1 mW/cm^2.**

Equation from page 18 of OET 65, Edition 97-01

$S = P G / 4\pi R^2$

where,
S = Power Density mW/m^2
P = Power (mW)
R = Distance to the center of radiation of the antenna
G = Maximum antenna gain

Maximum antenna gain for EUT = 0 dBi

P = 0.525 mW
R = 20 cm
G = 1 (numeric)

$S = 0.535*1 / 4(3.1416)(20)^2$

$S = 0.0001061$ mW/cm^2

Therefore, EUT meets the Uncontrolled Exposure limit at 20cm.

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(g) Frequency Stability

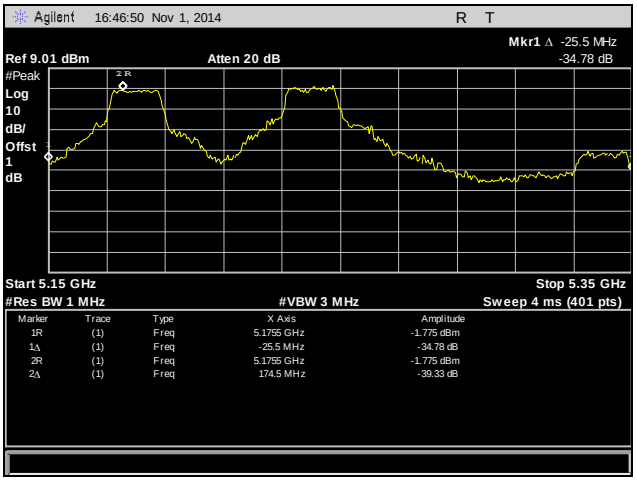
Test Requirements: **§ 15.407(g):** Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

Test Procedure: The EUT was connected directly to a spectrum analyzer through a attenuator. The resolution band width of the spectrum analyzer was set to 10 KHz. The 1st trace of the Spectrum Analyzer was used as a reference at 23°C. A 2nd trace was used to show the drift of the carrier at extreme conditions. A delta marker was used to find the drift at a given extreme condition. The two frequencies (i.e. 5300 MHz and 5550 MHz) are derived from one oscillator. Therefore, only one channel was investigated for frequency stability.

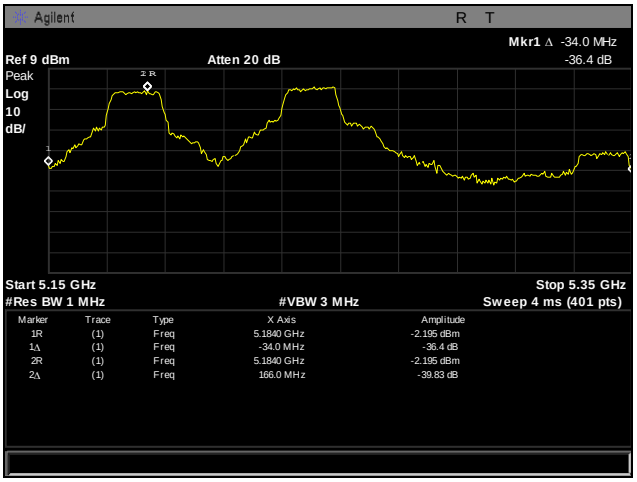
Test Results: The EUT was compliant with the requirements of **§15.407(g)**.

Test Engineer(s): Andy Shen

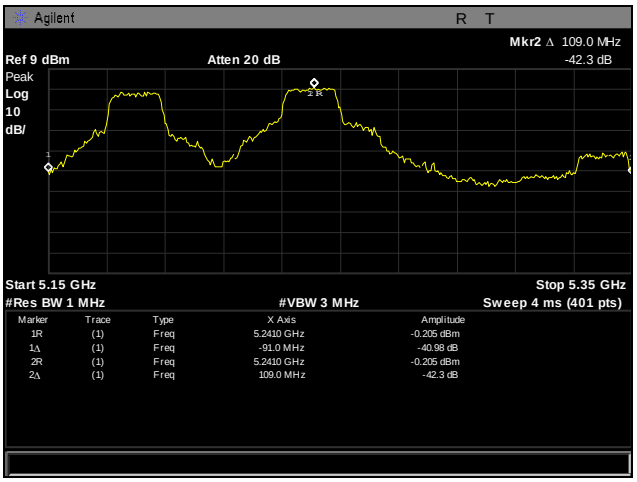
Test Date(s): 11/03/14



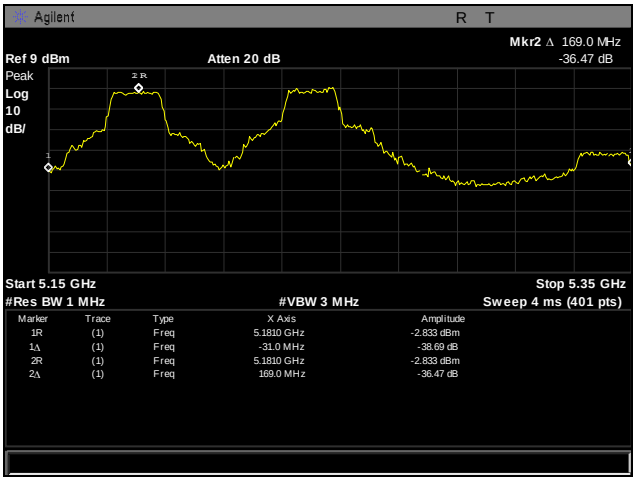
Plot 59. Frequency Stability, 5150-5350 MHz, -30°C, 120°C



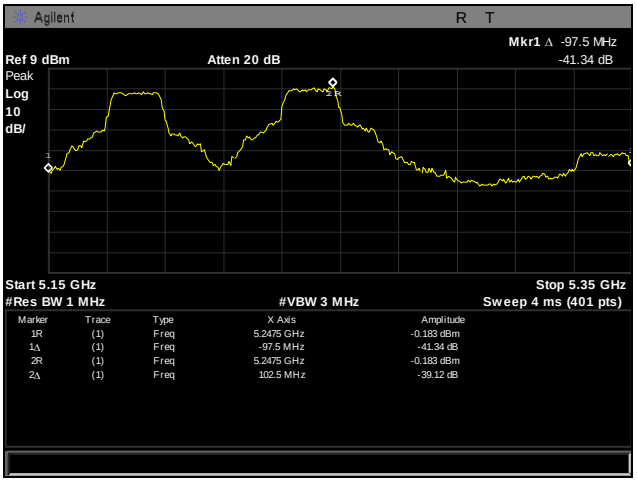
Plot 60. Frequency Stability, 5150-5350 MHz, -20°C, 120°C



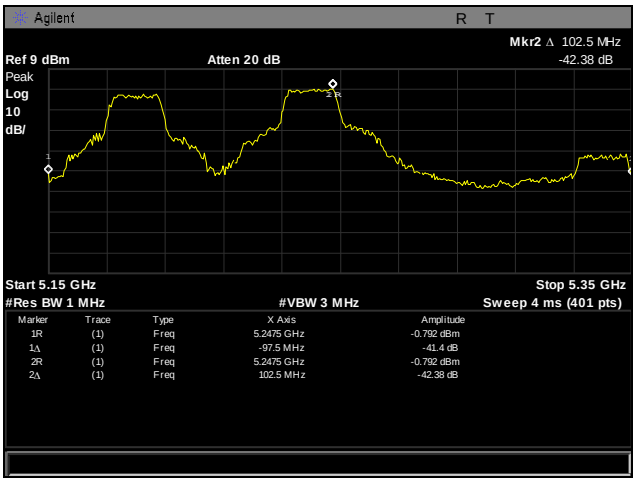
Plot 61. Frequency Stability, 5150-5350 MHz, -10°C, 120°C



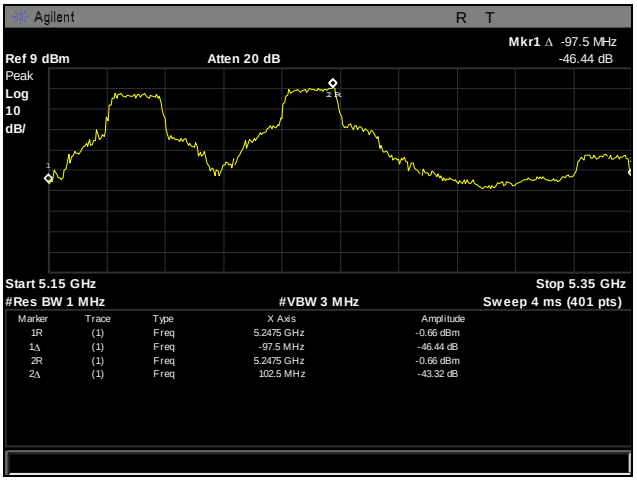
Plot 62. Frequency Stability, 5150-5350 MHz, 0°C, 120°C



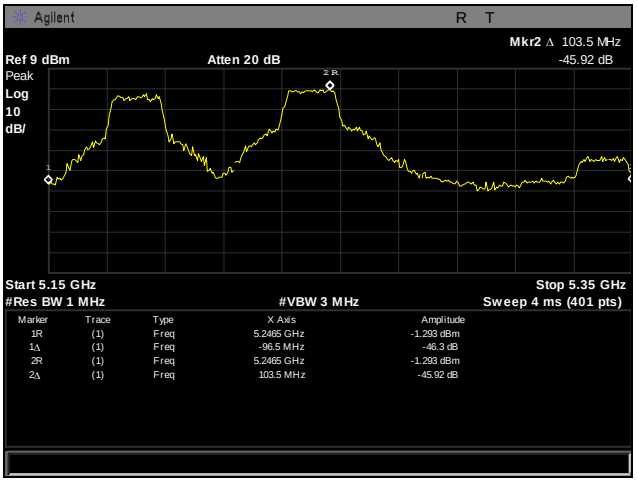
Plot 63. Frequency Stability, 5150-5350 MHz, 10°C, 120°C



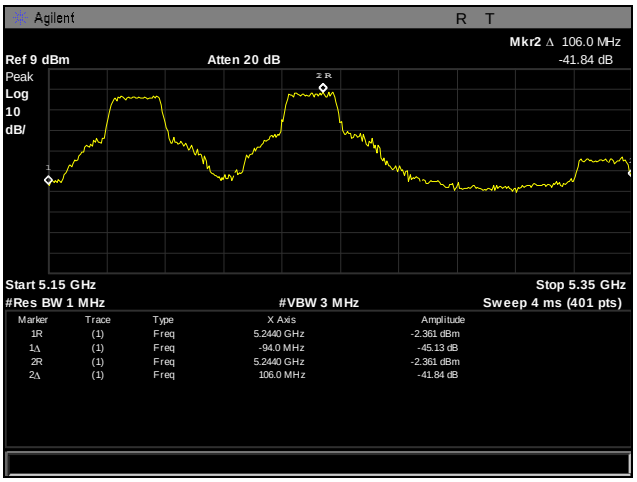
Plot 64. Frequency Stability, 5150-5350 MHz, 20°C, 120°C



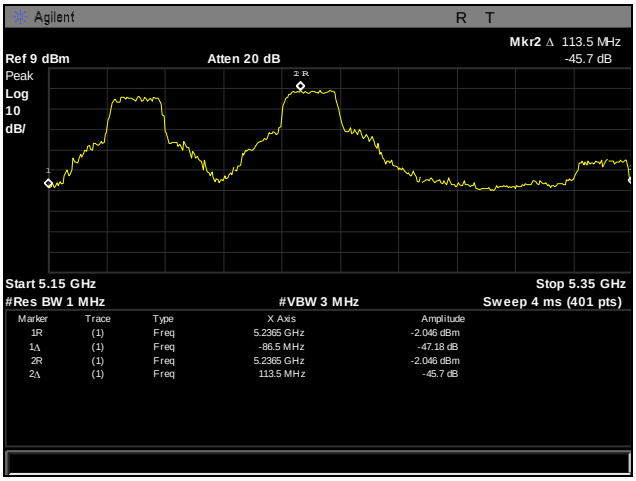
Plot 65. Frequency Stability, 5150-5350 MHz, 30°C, 120°C



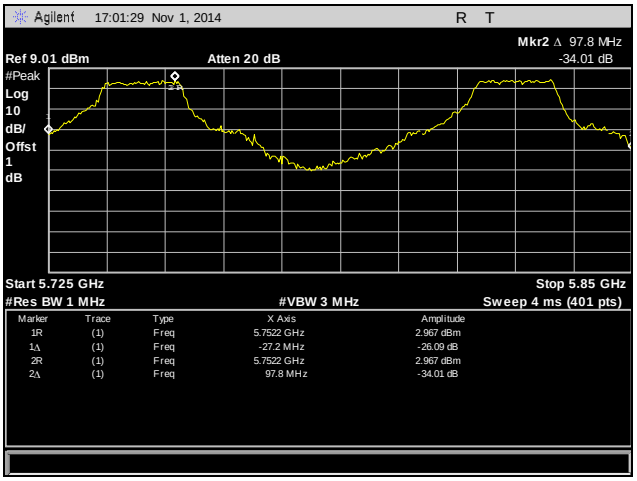
Plot 66. Frequency Stability, 5150-5350 MHz, 40°C, 120°C



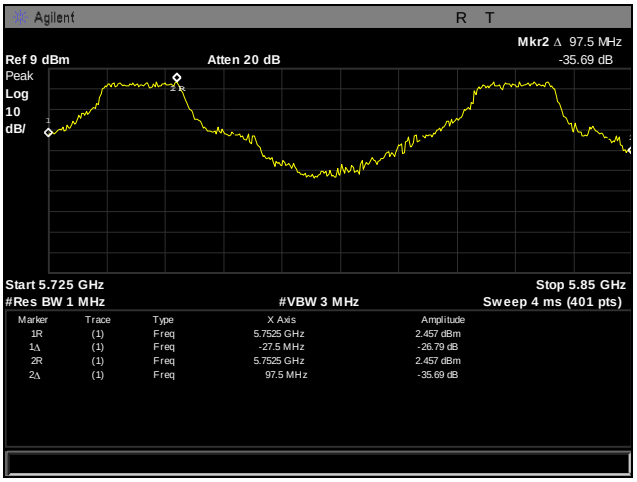
Plot 67. Frequency Stability, 5150-5350 MHz, 50°C, 120°C



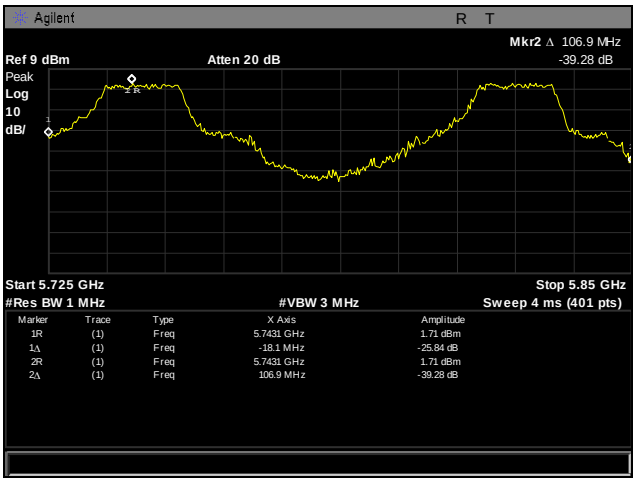
Plot 68. Frequency Stability, 5150-5350 MHz, 55°C, 120°C



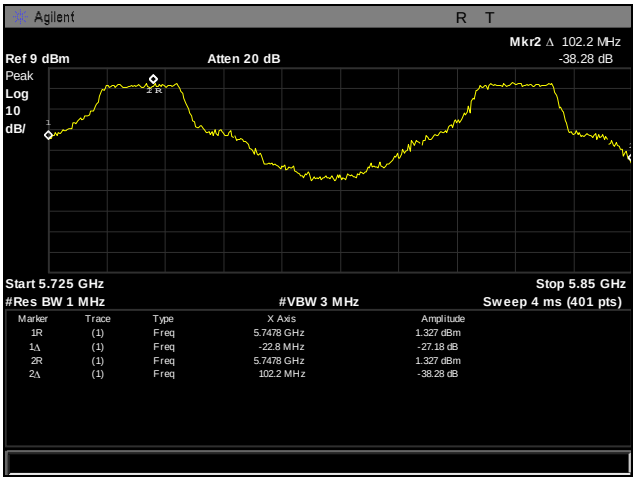
Plot 69. Frequency Stability, 5725-5850 MHz, -30°C, 120°C



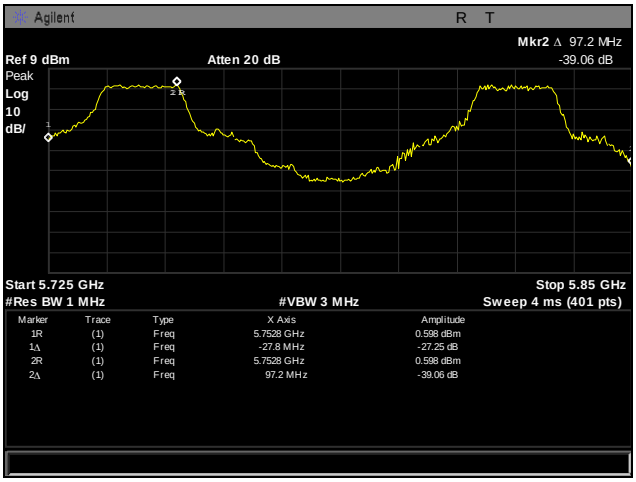
Plot 70. Frequency Stability, 5725-5850 MHz, -20°C, 120°C



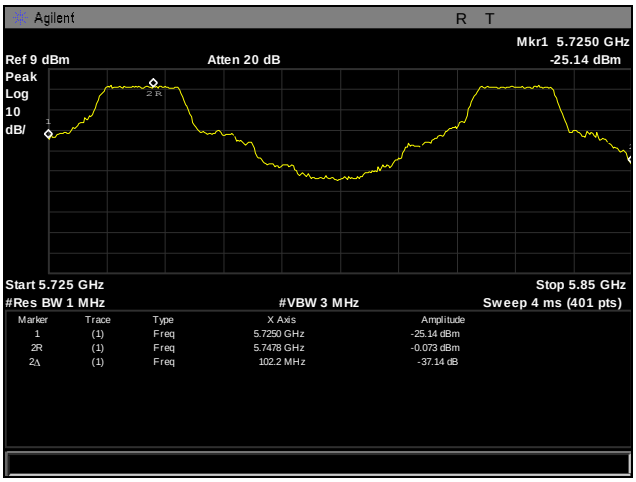
Plot 71. Frequency Stability, 5725-5850 MHz, -10°C, 120°C



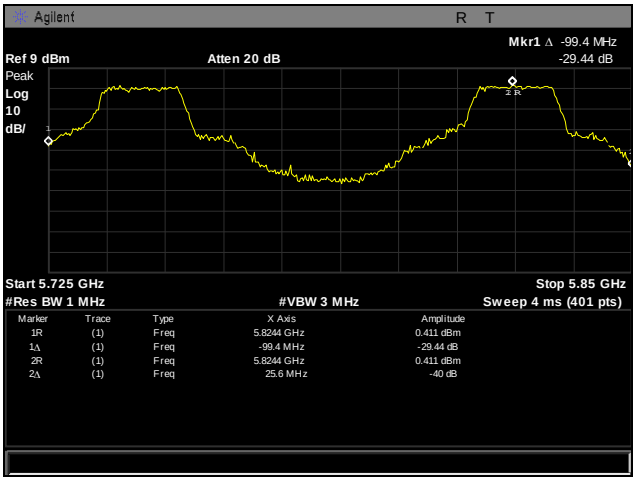
Plot 72. Frequency Stability, 5725-5850 MHz, 0°C, 120°C



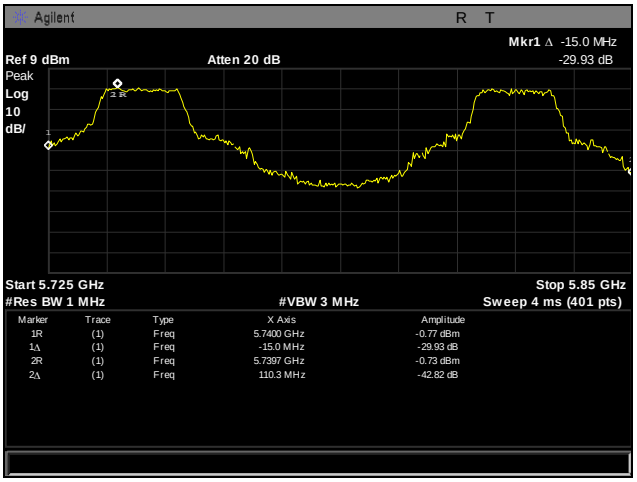
Plot 73. Frequency Stability, 5725-5850 MHz, 10°C, 120°C



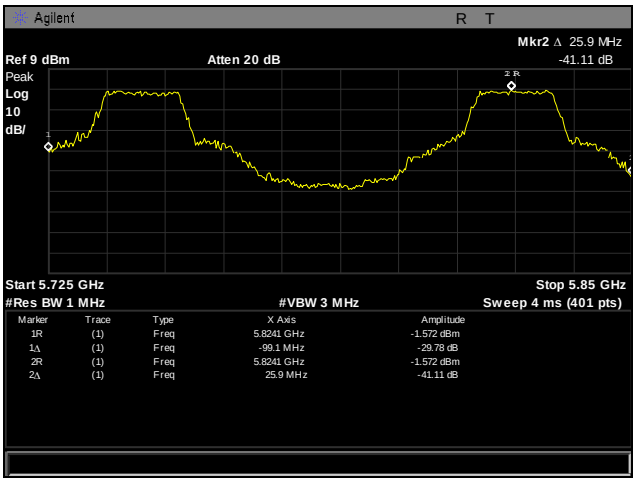
Plot 74. Frequency Stability, 5725-5850 MHz, 20°C, 120°C



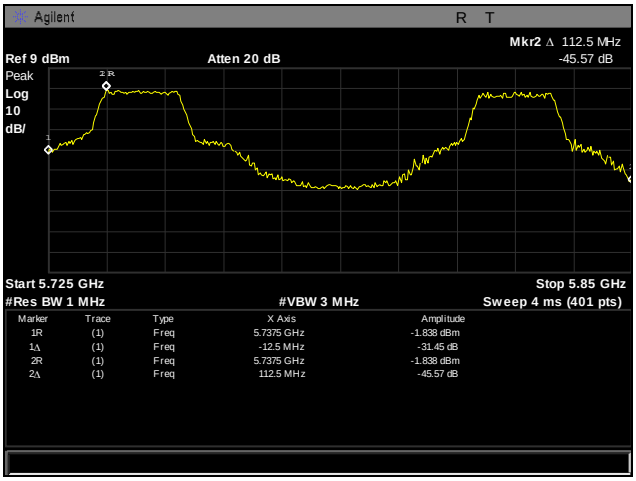
Plot 75. Frequency Stability, 5725-5850 MHz, 30°C, 120°C



Plot 76. Frequency Stability, 5725-5850 MHz, 40°C, 120°C



Plot 77. Frequency Stability, 5725-5850 MHz, 50°C, 120°C



Plot 78. Frequency Stability, 5725-5850 MHz, 55°C, 120°C

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2005.

MET ASSET #	EQUIPMENT	MANUFACTURER	MODEL	LAST CAL DATE	CAL DUE DATE
1S2460	1-26GHZ SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4407B	SEE NOTE	
1S2460	1-26GHZ SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4407B	2/27/2014	8/27/2015
1S2229	TEMPERATURE CHAMBER	TENNY ENGINEERING	T63C	9/18/2013	3/18/2015
1S2421	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESIB7	9/10/2014	9/10/2015
1S3853	DIGITAL DC POWER SUPPLY	EXTECH INSTRUMENTS	382200	SEE NOTE	
1S2482	5 METER CHAMBER (NSA)	PANASHIELD	5 METER SEMI-ANECHOIC CHAMBER	8/12/2013	2/12/2015
1S2600	BILOG ANTENNA	TESEQ	CBL6112D	8/29/2013	8/29/2015
1S2603	DOUBLE RIDGED WAVEGUIDE HORN	ETS-LINDGREN	3117	4/24/2013	4/24/2015
1S2421	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESIB7	9/10/2014	9/10/2015
1S3835	PSA SPECTRUM ANALYZER	AGILENT	E4448A	9/24/2014	9/24/2015
1S2460	1-26GHZ SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4407B	2/27/2014	8/27/2015
1S3853	DIGITAL DC POWER SUPPLY	EXTECH INSTRUMENTS	382200	SEE NOTE	
1S2399	TURNTABLE CONTROLLER	SUNOL SCIENCE	SC99V	NOT REQUIRED	
1S2121	PRE-AMPLIFIER	HEWLETT PACKARD	8449B	SEE NOTE	

Table 11. Test Equipment List

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

V. Certification & User's Manual Information

Certification & User's Manual Information

A. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

§ 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

(a) The various types of radio communication transmitting devices described throughout this chapter.

(b) The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.

(c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.

(d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

§ 2.803 Marketing of radio frequency devices prior to equipment authorization.

(a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:

(1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or

(2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.

(d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.

(e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:

(i) Compliance testing;

(ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or

(v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.

(e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.

(f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.

Certification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J — Equipment Authorization Procedures:

§ 2.901 Basis and Purpose

(a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.[1] *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer*, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.

(b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

§ 2.907 Certification.

(a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.

(b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

[1] In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.

Certification & User's Manual Information

§ 2.948 Description of measurement facilities.

(a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.

(1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.

(i) If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.

(ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.

(2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

Certification & User's Manual Information

Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

§ 15.19 Labeling requirements.

(a) In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:

(1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

(2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

(3) All other devices shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

(4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

(5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Verification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

§ 15.105 Information to the user.

(a) For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

(b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

– Reorient or relocate the receiving antenna.

– Increase the separation between the equipment and receiver.

– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

– Consult the dealer or an experienced radio/TV technician for help.

ICES-003 Procedural & Labeling Requirements

From the Industry Canada Electromagnetic Compatibility Advisory Bulletin entitled, "Implementation and Interpretation of the Interference-Causing Equipment Standard for Digital Apparatus, ICES-003" (EMCAB-3, Issue 2, July 1995):

> "At present, CISPR 22: 2002 and ICES technical requirements are essentially equivalent. Therefore, if you have CISPR 22: 2002 approval by meeting CISPR Publication 22, the only additional requirements are: to attach a note to the report of the test results for compliance, indicating that these results are deemed satisfactory evidence of compliance with ICES-003 of the Canadian Interference-Causing Equipment Regulations; to maintain these records on file for the requisite five year period; and to provide the device with a notice of compliance in accordance with ICES-003."

Procedural Requirements:

According to Industry Canada's Interference Causing Equipment Standard for Digital Apparatus ICES-003 Issue 5 August 2012:

Section 6.1: A record of the measurements and results, showing the date that the measurements were completed, shall be retained by the manufacturer or importer for a period of at least five years from the date shown in the record and made available for examination on the request of the Minister.

Section 6.2: A written notice indicating compliance must accompany each unit of digital apparatus to the end user. The notice shall be in the form of a label that is affixed to the apparatus. Where because of insufficient space or other constraints it is not feasible to affix a label to the apparatus, the notice may be in the form of a statement in the users' manual.

Labeling Requirements:

The suggested text for the notice, in English and in French, is provided below, from the Annex of ICES-003:

> This Class [2] digital apparatus complies with Canadian ICES-003.
>
> Cet appareil numérique de la classe [1] est conforme à la norme NMB-003 du Canada.

[2] Insert either A or B but not both as appropriate for the equipment requirements.

End of Report

